The Geography of Victoria

HISTORICAL, PHYSICAL, and POLITICAL

BY

J. W. GREGORY, D.Sc., F.R.S.

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Mt. Kurtweeton. Mt. Elephant. Lake Kolongulac.

View across the Volcanic Plains of Western Victoria, with the craters of Mt. Elephant and Mt. Kurtweeton, and the dry bed of Lake Kolongulac.

(From a sketch by A. G., from Gnotuk, near Camperdown.)

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MELBOURNE:

CHRISTCHURCH, WELLINGTON, DUNEDIN, N.Z., & LONDON

WHITCOMBE AND TOMBS LIMITED

To

E.E.C.

WHO TAUGHT ME—AMONGST MUCH ELSE—
TO REALISE THE EDUCATIONAL VALUE
OF GEOGRAPHY.

PREFACE.

As it is little more than three years since I first landed in Victoria, the main need of this preface is to apologize for my presumption in writing a book on its geography, to confess ignorance, and express gratitude to the many friends, without whose help this book would be even more incomplete than it is. The short time available for my study of the geographical structure of Victoria has been reduced by a fatality, that has prevented my devoting to field work in this State, any one of the three periods "of double drill and no canteen," technically called "long vacations." However, I have been able to visit most parts of the State, and to examine personally all the localities on which stress is herein laid. The book is an expansion of a course of University Extension Lectures given last year, during which I felt the need of some book treating the geography of Victoria in relation to the development of its topography. A new comer has some advantage in undertaking such a work, for he most feels the need of a general plan of the State, and of an explanation of the relations between the different geographical divisions.

The main duty of this preface is to express my indebtedness to the many friends who have helped me with information, and have kindly answered my persistent, and often troublesome questions. The two men who have suffered most from my geographical inquisitiveness are Mr. A. W. Howitt, the most clear-sighted of Victorian geographers, and Mr. Baracchi, the Government Astronomer; and they have always suffered me gladly. Much suggestive information about districts, of which the best maps are inadequate or incorrect, I owe to many swagsmen and prospectors, who, while we have shared a billy of tea on the roadside or on the mountain track, have given me the benefit of their intimate acquaintance with the back-blocks of Victoria. I must also express my best thanks to Professor Kernot, Professor Spencer, and Mr. T. S. Hall, of the University; to all my colleagues in the Geological Survey; to Mr. T. F. Morkham, the Secretary for

Lands; Mr. F. Tate, the Director of Education; Mr. A. S. Kenyon, of the Water Supply Department; Mr. Hardy, of the Lands Department; and Mr. J. H. Coane. I am indebted for the weather maps (Fig. 106-110) to Mr. Baracchi; for photographs to Mr. A. E. Kitson (Fig. 14, 16, 24, and 72), Mr. W. Ferguson (Fig. 18 and 36), Mr. H. J. Grayson (Fig. 19, 34, 90, 93, and 94), and to Mr. W. Bradford, of Ballarat East, for Fig. 27. Fig 48 is from a survey by Mr. J. Easton. Fig. 43 is from a diagram by Professor Kernot. The Frontispiece is reproduced from a sketch by my wife. Mr. Baracchi has removed from me the temptation of libelling the Victorian climate, by himself contributing a short sketch on that subject.

J. W. G.

June, 1903.

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PART I.—HISTORICAL GEOGRAPHY.

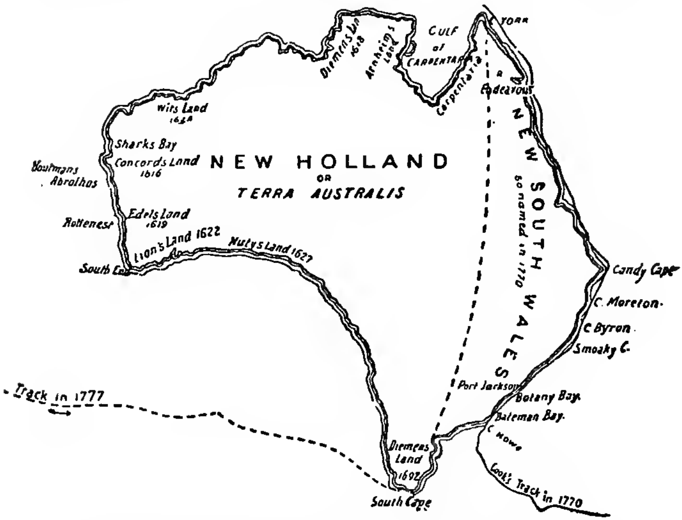
CHAPTER I.—SITUATION AND EXTENT OF VICTORIA.

VICTORIA is the State in the south-eastern corner of the continent of Australia. It lies between the 34th and 39th parallel of south latitude, and the 141st and 150th meridian of east longitude. The length from east to west is 420 miles; the breadth from north to south is 250 miles. It has a coast line of 600 miles. The area is 87,884 square miles, or 56,245,760 acres. Some small islands in the northern part of Bass Strait belong, geographically, to Victoria, which maintains the lighthouses upon them, and pays the expenses entailed there; but they belong, politically, to Tasmania.

CHAPTER II.—THE DISCOVERY AND COLONISATION OF VICTORIA.

THE land of Victoria was discovered by Captain—then Lieutenant—**Cook** on 19th April, 1770. On his voyage from New Zealand to Australia, he failed to reach the coast of Van Diemen's Land as soon as

he expected; and the first land, instead of trending from north to south, was found to run from north-east to south-west. The most southern point of this coast line Cook named Point Hicks, after his lieutenant, who first sighted it. Cook recognised that he had entered either a gulf or a strait; and he was inclined to believe that it was a gulf, as the sea fell so quickly



Map showing Cook's Voyages. From an Atlas published in 1798.

after the wind had died away. This fact suggested that Tasmania was joined to Australia, and that the eastern part of what we know as Bass Strait was thus protected from the western swell. But Cook had to leave this problem unsolved, and went his way "doubtful whether they [Tasmania and Australia] are one land or no."*

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* W. J. L. Wharton—Captain Cook's Journal. being the first voyage round the world made in H.M. Barque *Endeavour*, 1768-71. A literal transcript of the original manuscript 1893. p. 237.

Cook's colleague, Furneaux, in 1773, visited Bass Strait to settle this question; he was convinced "that there is no strait between New Holland [Australia] and Van Diemen's Land, but a very deep

Surgeon Bass.

(From a portrait in the possession of Mr. J. J. Shillinglaw, Melbourne.)

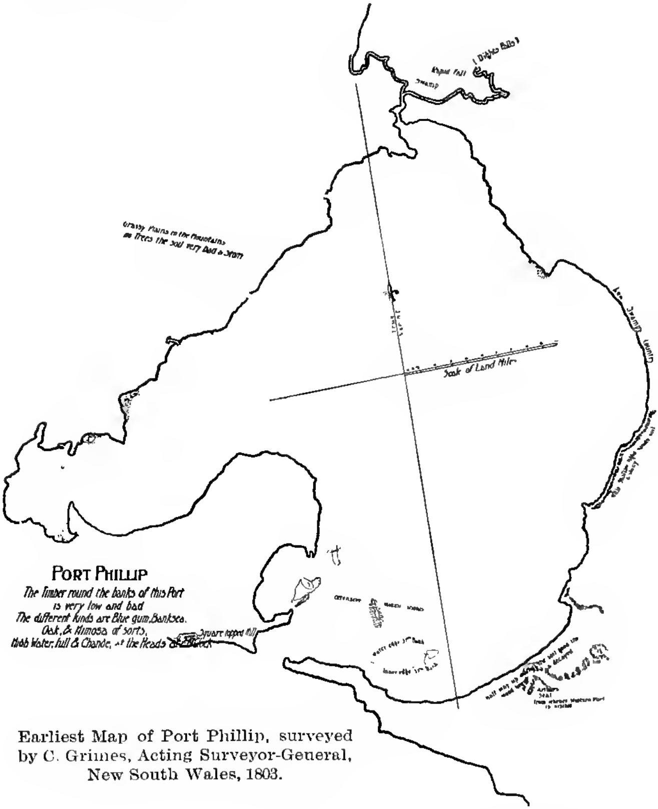
bay." Captain Hunter, in 1793, from the evidence of the tides, suggested that Tasmania is an island. This fact was first proved in 1797-98, in a courageous journey by Surgeon **Bass**, who sailed from Sydney in an open boat, and entered the strait that now bears

his name. He landed at Ram's Head on 19th December, 1797, and was thus the first European to set foot in Victoria. He failed to identify Cook's Point Hicks, which according to Sir William Wharton* was not a promontory, but "was merely a rise on the coast line where it dipped below the horizon to the westward; and the name of Point Hicks Hill is now borne by an elevation that seems to agree with the position." Bass worked westward along the coast, round Wilson's Promontory, and on the 4th January, 1798, he entered Western Port by its eastern entrance. The failure of his provisions compelled him to return. But the heavy swell that was running from the west showed him that the sea between Tasmania and the opposite coast of Australia was a strait and not a gulf.

The first visit to Victoria from the west was made in 1800 by Lieutenant **Grant**, in the *Lady Nelson*. He sailed the whole length of Victoria, and named most of the principal headlands on the southern coast. His chief contribution to Victorian geography was the discovery of a bay between Cape Otway and Cape Schanck, which he named King's Bay, after Governor King. Grant missed Port Phillip, which was first entered by a seaman named Bowen on the 1st February, 1802. Bowen was then in charge of a boat belonging to the *Lady Nelson*, which, with its commander, Lieutenant **Murray**, entered Port Phillip on the 15th February, 1802. He named Arthur's Seat, from a fancied resemblance to the mountain behind Edinburgh. He was closely followed by **Flinders**, who sailed into Port Phillip on the 26th April, 1802. With his usual energy Flinders

* Wharton, op. cit., p. 237.

explored the southern coasts of the port and ascended Station Peak, the highest point of the You Yangs. He named, amongst other points, Indented Head.



Earliest Map of Port Phillip, surveyed by C. Grimes, Acting Surveyor-General, New South Wales, 1803.

The first circumnavigation and survey of Port Phillip was made by **Grimes**, a surveyor sent by Governor King to examine its suitability for a convict settlement. Grimes sailed round the Bay in January

and February, 1803. He discovered the Yarra, which he ascended as far as Dight's Fall; his boat could not cross it, so he walked over the hill now occupied by Studley Park. During this boat journey, Grimes visited the site of Melbourne, which he thought a good situation for a settlement. James Fleming, in his account of this expedition, remarks that "the most eligible place for a settlement I have seen is on the Freshwater River," the name by which Grimes described the Yarra.

Colonel Collins.

In the same year (1803), an expedition was sent from England under Lieutenant Colonel Collins to found a convict settlement in Port Phillip. The two ships entered Port Phillip on the 10th October. In spite of Grimes's report of the existence of suitable country on the northern shore, Collins landed his party, on the 16th October, eight miles east of the entrance, on the most sandy and barren part of the Bay. Colonel Collins was very dissatisfied with the locality; he described it "as this unpromising and unproductive country." He declared that Port Philip could never be commercially valuable, as the entrance is so bad; and that "every day's experience convinces me that it cannot, nor ever will be resorted to by speculative men." Collins quaintly remarks

about the sand dunes of that area, that "the soil . . . . . . is light and mixed considerably with sand." The Sydney "Colonist" subsequently complained that Collins placed "the settlement on the only piece of sterile land within the Heads." Water was obtained from casks sunk in the sand on the shore. The quality was good, and the supply regular; but Collins was doubtful, quite unnecessarily, about its permanence. So on the 26th January, 1804, the whole force was re-embarked and removed to Tasmania. Collins's motives for this change of locality have been differently explained. Many of his party were enthusiastic about Port Phillip. Mrs. Hopley—the wife of one of the surgeons—wrote, "my pen is not able to describe half the beauties of that delightful spot. Much to my mortification as well as loss, we were obliged to abandon the settlement through the whim and caprice of the Lieut.-Governor." The removal has been attributed to the fact that Collins had been promised an extra £500 if he found Port Phillip unsuitable, and had to move to another locality.

After the withdrawal of the convict expedition of 1803, the country was neglected, and appeared to justify the prediction by Tuckey, one of Collins's officers, that it would be left for ever to the kangaroos. The coast was visited only by occasional sealers and whalers, until the journey of Hume and Hovell in 1824-5. These explorers started overland from the backblocks of New South Wales. They worked south until they saw in the distance a snow-covered range of mountains, which they called the Alps. They discovered near Albury the river now known as the

Murray, and named it the Hume River; they crossed it by a boat made of sticks and tarpaulin. They reached the Ovens and the Goulburn Rivers, the latter of which they named the Hovell. Unfortunately for themselves, they left the valley by which the railway line to Sydney now crosses the main divide; they followed one of the tributaries of the Goulburn, till they got amongst the densely timbered ranges near Mount Disappointment. Thence they saw Mount Wentworth, now known as Mount Macedon. They were driven westward from the hills to the lower country, and, crossing the main divide, reached the basalt plains of the Melbourne basin. They passed the You Yangs and reached Geelong on the 15th December, 1824. Hovell identified the locality as the shore of Western Port; and, as he was a sea captain and had been sent with the expedition as the observer, his erroneous view was officially accepted. This mistake delayed the settlement of Victoria for another ten years.

Hume's description of the southern plains was so inspiriting, that it was resolved to establish a settlement upon them. An expedition was sent from Sydney by sea; but, owing to Hovell's mistake, it of course went to Western Port. It left Sydney on the 9th November, 1826, and, on the 12th December established itself at Settlement Point, on the eastern shore of Western Point: it founded a fort which was named Fort Dumaresq, in compliment to Dumaresq, the commander of a French expedition then visiting Southern Australia. Some sealers were found in a temporary station on Western Port; but the land was not equal to the expectations based on Hume and Hovell's

descriptions of the country which they had reached; and so the colony was abandoned in January, 1828. This settlement was, however, of considerable indirect importance, as news of it aroused much interest in Tasmania. G. T. Gellibrand and John Batman, two residents on that island, applied on the 11th January, 1827, for a grant of land on Western Port. They offered to stock it with from 15,000 to 20,000 sheep, and 30 cows. This application was declined by the Government on the 22nd March, 1827, and the settlement of Victoria was again postponed.

Meanwhile some whalers had formed a permanent settlement on the western coast of Victoria, at Portland. The chief settlers were the family of the **Hentys**, who landed at Portland on the 19th November, 1834. They built a house (Richmond Cottage), and established a garden on the shores of the Bay. They had no formal concession; but they unwisely trusted to an understanding with the Government, that, in the event of the settlement of the country, their claims to any land that they had cultivated or occupied would be favourably considered.

In 1836, the most important geographical expedition that has ever worked in Victoria entered the country from the north; it was under **Sir Thomas Mitchell**, the Surveyor-General of New South Wales. He crossed the Murray at Swan Hill, passed the crescentric ridges of Mount Boga, discovered and named the Rivers Yerrayne (Loddon), Avoca, Wimmera, Glenelg, and Campaspe. He saw and named the Grampians, the Pyrenees, and Mount Macedon. He was charmed with the whole country, and named it "Australia Felix." He described it as "a region

more extensive than Great Britain, equally rich in point of soil, and which now lies ready for the plough in many parts, as if prepared by the Creator for the industrious hands of Englishmen." Thanks to his glowing descriptions, the failures of Collins, and of the missions to Western Port were all forgotten, and immigration into Victoria at length began in earnest. It set in from two sources. Mitchell's reports of the richness of the country round Port Phillip, and his demonstration of the practicability of the overland route to it, led some of his fellow residents in New South Wales to move southward. They settled in the valleys of the southern tributaries of the Murray. This line of immigration is well known from our classic novel, Henry Kingsley's "Geoffrey Hamlyn."

Fig. 5.— Sir Thomas Mitchell.

The number of immigrants working southward from the Murray was small, however, compared with that of Tasmanian settlers working northward from the coast. The difficulties of the overland journey from Sydney rendered it geographically

inevitable, that Victoria should be developed as a dependency of Tasmania, rather than as the hinterland of New South Wales. The real colonisation of Victoria began in 1835, with the foundation in Tasmania of the

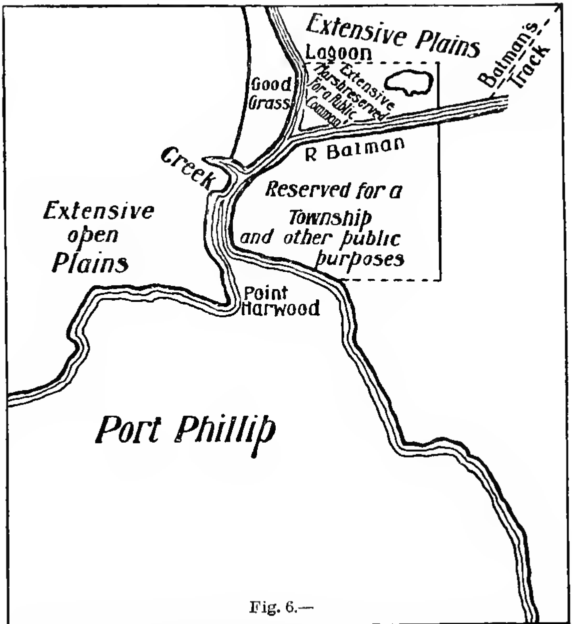


Fig. 6.—

PART OF BATMAN'S MAP INCLUDING THE AREA AROUND MELBOURNE 1835.

Port Phillip Association. This Association consisted of a party of Tasmanian farmers, at the head of which was **John Batman.**

He crossed from Tasmania, in 1835, in the *Rebecca,* in order to select land suitable for sheep farming, on behalf of the Association. He visited Port

Phillip, and saw the open basalt plains to the south and west of Melbourne, which he thought eminently suitable for sheep runs. He described the country as "decidedly superior to any which I have ever seen." He visited the site of Melbourne, and decided to establish headquarters on South Melbourne, declaring this "will be the place for a village." On his sketch map, he marked the ground between the Yarra—which is there named "R. Batman"—and Hobson's Bay, as "reserved for a township and other public purposes." The ground on the opposite side of the river, between the Saltwater River and the lagoon, he marked as "extensive marsh, reserved for a public common." He made friends with the natives, a tribe named the Dutigalla, and, on the 6th June, 1835, signed a treaty with them, based on Penn's famous treaty with the North American Indians. It arranged for the purchase of some 640,000 acres north and north-east from Melbourne, in exchange for annual payments of blankets, knives, flour, etc. Having made these preliminary arrangements, Batman returned to Tasmania, to bring over more of his party, and get official sanction for his land purchase. The Governor of Tasmania, however, could not himself recognise the "rights supposed to have been acquired by the treaty," but referred the matter to the Home Government.

While Batman was negotiating in Tasmania, a rival company of Tasmanians settled in Victoria. This party left Tasmania in a schooner, the *Enterprise*, in July, 1835. Their leader, **J. P. Fawkner**, was taken so seasick that he was landed on the coast of Tasmania. The others went on, and

reached Western Port, where they could not find a locality that answered their requirements ; for Fawkner had laid it down as essential that the settlement must be placed beside a freshwater river. The party then proceeded to Port Phillip, and cruised along its eastern shore ; they found nothing suitable

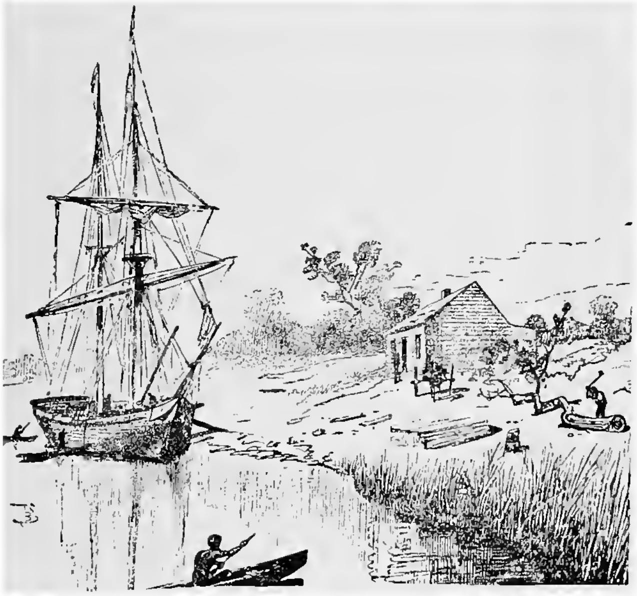


Fig. 7.—Fawkner's House on the Yarra.

until they came to the Yarra. They rowed up the river in a whale boat, and landed on the site of Melbourne on the 22nd August, 1835. They were so attracted by the situation, that they resolved to settle there. In spite of the many snags in the river, they brought their schooner up the Yarra, landed stores and horses, and built a hut. They began cultivation,

and the *Enterprise* went back to Tasmania on the 5th September. Fawkner came over at once, and landed on the 10th October. In the meanwhile, a protest against the right of Fawkner's party to the ground had been made on behalf of the Port Phillip Association. Batman, anxious to avoid any risk of trouble with the natives, had thought it better to leave his men at the Indented Heads, near Queenscliff. They had been joined by Wedge, a surveyor, who, hearing of Fawkner's arrival, hastened to Melbourne, and, in virtue of Batman's treaty, ordered the new comers to quit. The order was rejected, and Fawkner's party, therefore, founded Melbourne, though Batman had previously selected Port Melbourne and South Kensington as the site for his capital.

The **Port Phillip settlement** was now an actual fact; but the Government refused either to sanction Fawkner's occupation, or to accept Batman's treaty. Colonel Arthur, the Lieutenant-Governor of Van Diemen's Land, was friendly to the settlers, and supported them as well as he could. He apparently thought that Port Phillip was so far from Sydney, that the country would develop as an appendage to Van Diemen's Land. He suggested to the Home Government, that this policy should be followed. Sir Richard Bourke, Governor of New South Wales, was irritated by this proposal, and adopted an attitude of hostility, both to the settlers and Colonel Arthur. Bourke, on the 26th August, 1835, issued a proclamation, declaring that the territory was within the limits of New South Wales, that all the settlers were trespassers, and were liable to be dealt with as such. Colonel Arthur had to accept this declaration, and, on

the 28th January, 1836, he admitted that he could not further interfere in the affairs of the young settlement. The Port Phillip Association had made the mistake of ignoring the Sydney authorities, or, as in its first letter, referring to the lands as beyond the jurisdiction of New South Wales. It made a direct appeal to the Home Government, and Major Mercer was sent home to argue the case on behalf of the settlers. His efforts were in vain. There were powerful influences at work in England against the Association. The *Spectator* denounced the settlement as an illegal invasion, and declared that Colonel Arthur should have been punished for not having stopped it. The Government decided that the occupation of land by the Association was illegal; but the settlers were allowed to remain, though in other respects they were left to the tender mercies of Bourke. Batman's treaty was promptly dismissed; because the Home Government maintained that all Australia belonged to the British Crown, by virtue of its discovery by Captain Cook. According to this view, the aborigines were not the owners of the land, and, therefore, could not sell it to Batman. The only valid title to land was purchase from the British Crown. A promise was, however, given that, in acknowledgment of the work done by Batman and Fawkner's parties, they should be allowed to purchase the land they had occupied at a reduced upset price, and the Association was allowed to deduct up to the amount of £7000 for its expenses. To place the settlement on a legal footing, a Land Act was passed on the 29th July, 1836, "to restrain the unauthorised occupation of Crown lands."

Meanwhile other parties had come forward, and also applied for land. One group known as "The Memorialists" included Aitkin and Steele, whose names, with those of most of the leading settlers at this period, are preserved in Victorian place names. Another company contained Clark, Lewis, Sutherland, and four others. The number of settlers was thus rapidly increasing. As there was much jealousy between the members of the Association, of Fawkner's party and the groups of later arrivals, something had to be done to keep the peace between them. So the people had a meeting, and appointed Simpson as arbitrator to settle all their disputes, until a proper government should be established.

Fig. 8.- Captain Lonsdale.

The growing importance of the settlement, however, soon forced the Sydney authorities to recognise it; and George Stewart, of Goulburn, was sent to report upon it. He wrote a very favourable account of the people, of whom there were 142 men and 32 women; and he gave a list of the seven tribes of aborigines then living in the district. His report compelled the authorities to undertake the administration of the settlement. So, in October, 1836, **Captain Lonsdale** was sent as Superintendent,

with Russell as surveyor. In March, 1837, Sir Richard Bourke visited the young township; and on this occasion he changed its name from the Port Phillip Settlement to **Melbourne**, after the English Premier. He found that the population had increased to over 200, and that they had spread over wide tracts of the Melbourne basin as far north as Macedon. Progress was still hindered by the long delay in giving the people legal titles to their lands. They could not build substantial houses, as by so doing they would only have raised the price they would have had to pay for their selections. Bourke therefore arranged the condition of the land sale, and the first was held on the 1st June, 1837. The average price realised was £35 per half acre. On the 14th June, Bourke recommended Colonel Snodgrass, then Acting-Governor of Van Diemen's Land, as Superintendent for Port Phillip; but this recommendation was not accepted by the Home Government. A Moravian, named **C. J. Latrobe**, who was greatly in favour with philanthropic circles in England, was appointed instead. He arrived in Melbourne on the 1st October, 1839.

After the land sale and the appointment of the Superintendent, immigration set in from England. Before that time, nearly all the Melbourne settlers had come from Tasmania. The first of the "overlanders"—those who came overland from Sydney—was Gardiner, of Gardiner's Creek. He arrived in 1836.*

The development of Port Phillip after 1839 involved long quarrels with Sydney, especially over

* The progress of settlement inland is given in Part III.

the management of the finances of the settlement. The people of Melbourne were anxious for independence, which was geographically necessary, because, at that time, the overland route was tedious and difficult. At the back of Sydney is a wide belt of mountainous country, which hinders communication with the interior: beyond the hills are back-bush and scrub-covered plains, even now but thinly settled. In northern Victoria is a mountainous belt stretching east and west, and separating the Murray valley from Port Phillip. Communication between Sydney and Melbourne, either overland or by the sailing ships then available, was therefore slow and precarious. Melbourne was young and growing rapidly, and its impulsive people could not brook the long delays involved by having to refer all matters of administration to a distant authority. Even had the interests of the two towns been the same, and had there been the fullest harmony between the two people, Sydney could not have satisfactorily managed the affairs of the new settlement. But the interests of the two districts were different, and the founders of Port Phillip were angry at their treatment by Bourke.

Fig. 9.—C J. Latrobe.

So disagreements were inevitable, and they led to a long and bitter quarrel.

The Home authorities were not indisposed to allow the separation of the Port Phillip district. The reform, however, was long delayed. In 1848 the people of Melbourne elected Lord Grey as their representative, to show the Home Government that they regarded it as a farce to send a member to a parliament in Sydney, at a time when communication was so difficult; and they subsequently nominated the Duke of Wellington, Lord Palmerston, Lord Brougham, Lord John Russell, and Sir Robert Peel as candidates for the remaining seats. Independence was at length granted, on the 1st July, 1851, and, it is said, by the Queen's special desire, the name of Port Phillip district, or Australia Felix, was changed to Victoria.

Chapter III.—BOUNDARIES.

The boundaries established by the new colony were perhaps unfortunate, and led to considerable trouble. The Colonial Office fixed the boundary from South Australia as the 141st meridian of longitude, heedless of the fact that, in the absence of telegraphic communication, the determination of meridians of longitude is a very difficult task. There was consequently a long wrangle with South Australia as to the exact position of the boundary; and Victoria now

includes a strip of territory 3′ 56″, or about 2 miles wide, which, according to the frontier verbally assigned, should have been included in South Australia.

The boundary with New South Wales was still more troublesome. It was drawn from the coast at Cape Howe in a straight line west-north-west, to Forest Hill ; thence it followed the course of the Murray to the border of South Australia. But the boundary was not defined as the thalweg* of the Murray, as is usually done when a river serves as a frontier line. And, with a river having so many branches as the Murray, the boundary adopted was especially unsatisfactory, and might easily have been the cause of serious difficulty. The boundary, moreover, left in New South Wales an area of which Melbourne was the natural outlet. The Murrumbidgee would have been a better geographical boundary, and was at first intended as such by the Home Government ; for when the Southern, or Port Phillip District, was established by Lord John Russell's despatch of 31st May, 1840, the boundary was fixed as the Murrumbidgee ; but Russell's successor, Lord Stanley, in consequence of protests from Sydney, altered the boundary to the Murray.

The boundaries of Victoria, however, are essentially determined by geographical features, as practically Victoria is separated from South Australia by the Western Desert, and from New South Wales by the line of the Murray.

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* The thalweg of a river is the line where the slopes of its two banks meet. Its position is marked by the line of the deepest water in the river. The word thalweg is a German word made up of the two words—thal, a valley, and weg a way or road.

CHAPTER IV.—REFERENCES TO LITERATURE.

The chief compilations which may be recommended are:—

G. W. Rusden—"The Discovery, Survey, and Settlement of Port Phillip," 8vo., Melbourne, 1871.

F. P. Labillière—"Early History of the Colony of Victoria," 2 Vols., London, 1879.

J. Bonwick—"Port Phillip Settlement." London, 8vo., 1883.

A. Sutherland—"Victoria and its Metropolis," 2 Vols., 4to., Melbourne, 1888.

The history of Melbourne from 1837 to the beginning of the gold diggings is well told in:—

T. McCombie's "History of the Colony of Victoria from its Settlement to the death of Sir Charles Hotham," 8vo., Melbourne, 1858.

The principal original contributions to the explorations of Victoria are as follows:—

Murray's account of his Voyage and Discovery of Port Phillip in 1803 was first published in Labillière.

M. Flinders—"Voyage to Terra Australia," 3 Vols., 1814. This includes the best account of Bass's work.

Jas. Grant—"Narrative of a Voyage of Discovery performed in His Majesty's Vessel the *Lady Nelson*, in the years 1800, 1801, and 1802 to New South Wales," 4to., 1803.

J. H. Tuckey—"Account of a Voyage to establish a Colony at Port Phillip, 1802-4," 8vo., 1805. This gives the story of the attempted convict settlement under Collins.

Grimes's Exploration of Port Phillip as recorded by the journal of his companion, Fleming, has been reprinted by J. J. Shillinglaw, Historical Annals of Port Phillip. Parl. Pap., Victoria. Melbourne, 1879.

W. H. Hovell and H. Hume—"Journey of Discovery to Port Phillip, New South Wales in 1824-25," 8vo., Sydney, 1837.

Hamilton Hume—"Brief Statement of Facts in connection with an Overland Expedition from Lake George to Port Phillip in 1824," 8vo., Sydney, 1855.

W. H. Hovell—Reply to do., 8vo., Sydney, 1855.

The records of the attempted settlement at Western Port in 1826-1828 are given by Labillière.

T. L. Mitchell—"Three Expeditions into the Interior of Eastern Australia," 2 Vols., 1839.

Part II.—PHYSICAL GEOGRAPHY.

Chapter I.—THE VICTORIAN COAST.

A. Exploration of the Coast.

As we have seen in the previous chapter, the coast line of Victoria was practically all discovered during the six years between December 1797 and 1803. The eastern end had been seen by **Captain Cook** in 1770, but he contributed very little to the geography of Victoria. He saw a hill to the south west of Cape Howe, and named it Point Hicks, under the impression that it was a headland. Bass Strait,

which separates Tasmania from Australia, was first proved to exist in December 1797 and January 1798, by **Surgeon Bass**, in an adventurous voyage from

Fig. 10.—Flinders.
(From a painting in the possession of Mr. J. Shillinglaw.)

Sydney in an open boat. The Strait was first completely traversed in a voyage by **Flinders** and **Bass**, later in 1798. The first full journey along the Victorian coast was made by **Lieutenant Grant**, in

1800. He saw all the chief headlands, and named some of them, such as Capes Bridgewater and Albany after Dukes, others such as Capes Otway, Schanck, Nelson, and Wilson's Promontory after naval officers, and one, Cape Liptrap, after a private London friend. Grant saw and named King Bay, but missed Port Phillip, which was discovered by **Murray's** expedition in 1802. Murray passed through the heads and saw Arthur's Seat. Port Phillip was first surveyed by **Grimes** in 1803, whose work completed the discovery of the Victorian Coast line.

B. The Two Coast Types.

If we look at a map of the **Atlantic,** we see that it occupies a long channel fairly regular in width and shaped somewhat like the letter S. In the second place, we notice that the islands upon it are scattered irregularly, as single islands such as St. Helena, worn down volcanoes such as Ascension, rock stacks as the smaller Trinidad, mere reefs such as the St. Paul's Rocks, or small archipelagoes such as the Canaries and the Azores. With the exception of the West Indies, the arrangement of the Atlantic islands is essentially irregular.

Thirdly, when we examine the course of the Atlantic shores, we notice that they hold no definite relation to the mountain lines of the adjacent continents. For example, in Europe the old Hercynian chain ends at the western end of Brittany; the Pyrenees are cut short at the north-western corner of Spain, in the once dreaded headland, which, owing to its sudden termination, received the

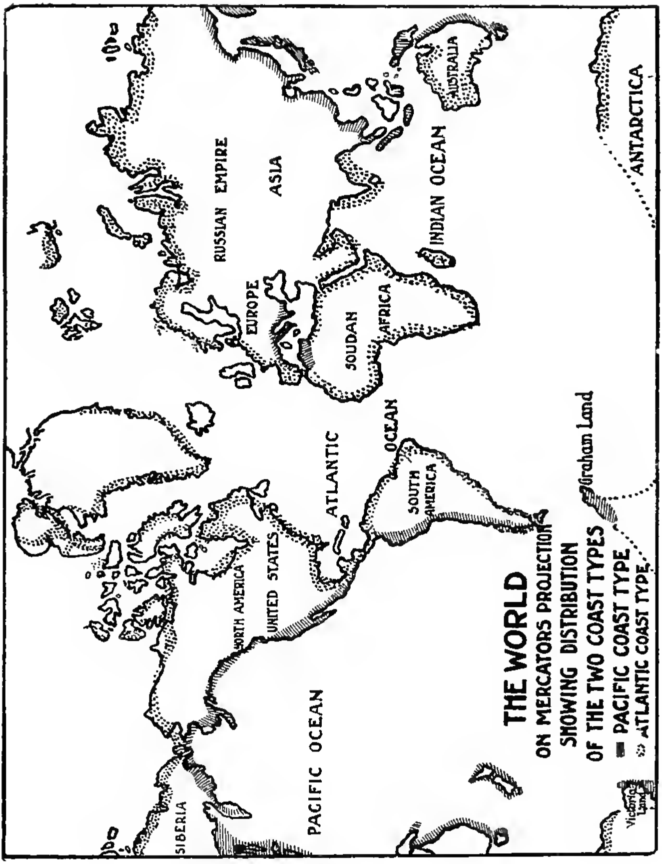
THE WORLD
ON MERCATORS PROJECTION
SHOWING DISTRIBUTION
OF THE TWO COAST TYPES
PACIFIC COAST TYPE
ATLANTIC COAST TYPE
RUSSIAN EMPIRE
ASIA
EUROPE
AFRICA
SOUDAN
INDIAN OCEAN
AUSTRALIA
ANTARCTICA
ATLANTIC
OCEAN
SOUTH AMERICA
NORTH AMERICA
UNITED STATES
PACIFIC OCEAN
SIBERIA
Graham Land
Victoria Land

Fig. 11.

name of Finisterre (Finis, the end; terre, land.) In Africa, the chain of the Atlas Mountains is truncated abruptly by the straight shore of Southern Morocco. Between the ends of these mountains the Atlantic shores are formed by long lines of low coastland, such as the Landes of Southern France, or by the bold bluffs of the Spanish peninsula. The characters of the shore are, in fact, accidental, and vary with the nature of the rocks which happen to outcrop upon the shore.

Fourthly, if we cross the Atlantic to the American coasts, we find a repetition of the same features. The east and west mountains of the Atlas and the Pyrenees are continued by the range of Venezuela and the main mountain line of the Greater Antilles; the rocky coasts of the Scandinavian plateau are repeated in Labrador. The great tableland of Equatorial Africa is similar, geologically, to the opposite tableland of Brazil. The low coast between Brittany and the Pyrenees is repeated in the sandy shores of the United States, lying between the mountains of Newfoundland, which recall the highlands of Brittany, and the backbone of Hayti and Cuba, which in some features resembles the Pyrenees.

Closer study shows us that this repetition of geographical type, upon the two coasts of the Atlantic, is dependent upon the identity of geological elements and structures. There is a striking resemblance between the geology of Newfoundland and Brittany, of Venezuela and the Atlas Mountains, of Brazil and the Equatorial plateau of Africa. The evidence shows that the trough of the Atlantic has been formed by a great subsidence cutting across the land area, which

occupied the present site of the Atlantic. Traces of this old Atlantis, which once linked the old world and the new, are still to be found on the few remaining islets and in the contours of the Atlantic floor.

The **Pacific Ocean** in all respects forms a striking contrast to the Atlantic. The shape is simple, and it is approximately that of a trigonal figure, that is, a triangle with convex sides. Its islands occur along definite lines.* There is one series which continues across the centre of the ocean from Malaysia to the north west end of the submerged Patagonian platform. Other islands occur in festoons, which garland the coasts and enclose inland seas. These festoons are most conspicuous along the coast of eastern Asia, where they enclose the Gulf of Okhotsk, the Sea of Japan, the Yellow Sea, and the Sea between Borneo and Tonquin. On the Australian coast we have the great festoon, which runs from New Guinea, through the New Hebrides and Norfolk Island, and is continued in New Zealand, enclosing the Coral and the Tasman Seas. Along the American coast these festoons are not so conspicuous, but a few of them may still be recognised. One series extends from Vancouver northward along the Pacific shores of Canada. The long peninsula of California is continued by some tiny islets and the Galapagos Group, which are probably the remnants of a great festoon that enclosed a sea like those off Eastern Asia. Off South America, Juan Fernandez and St. Felix probably form the last link of another island chain. On the Antarctic coast, Peter Island and the problematical islands seen by Cook may represent another of the Pacific festoons.

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* *See* Austral Geography Class VI. p. 123.

Looking at the Pacific coasts themselves, we see that the mountain chains occur in long series, parallel to the shores, the trend of which is directly determined by the mountain lines. We find this arrangement conspicuously shown all along America, (with the unimportant exception of Central America), as in the Andes in the South and the Sierra Nevada and Rocky Mountains in the North. In Asia we find this same arrangement in the mountain ranges of Kamstchatka and the Altai Range, and in Australia by the long mountain chain of eastern Australia.

Another difference between the Atlantic and the Pacific is brought out by a comparison of the shores of North America and Asia, or of South America and Australia; we see no suggestion of mountain ranges once continuous across the Pacific. The mountains are concentric with the ocean shores, instead of being transverse to them as in the case of the Atlantic.

These two types of coasts have been named by Suess, the Atlantic and the Pacific types. Their forms can best be explained on the view that the Pacific Ocean was due to one great movement of depression, which affected the whole Pacific face of the globe. The subsidences of the earth's crust under the Pacific gave a general outward thrust in all directions, which formed mountain chains concentric to its shores. In the Atlantic. on the other hand, the ocean has no such direct connection with the mountain lines of the adjacent continents. Their mountains were not formed by the same events that formed the ocean basin. The Atlantic, moreover, was not formed by one single movement; it has grown slowly by the gradual enlargement of two gulfs, which ran north and south

from a landlocked Mediterranean Sea, that once extended from Persia to the West Indies. By successive subsidences these two gulfs grew along the line of the Atlantic, until they had cut across the former land connection between the Old World and the New,

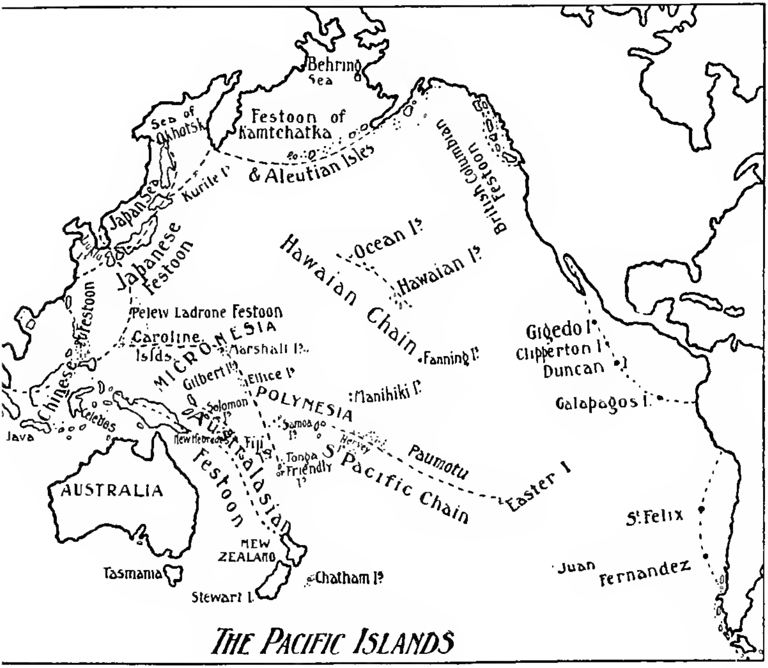


Fig. 12.

and established a direct channel between the Arctic and the Southern Oceans.

We have then to remember that the Atlantic type of coast is due to a long succession of disconnected subsidences, and that the mountain ranges on its shores are older than the Atlantic. The Pacific

has a simpler history, and the surrounding mountains were directly due to the thrusts caused by the subsidences of the Pacific floor.

If we glance at the distribution of these two coast-line types throughout the world, we find that the Atlantic type forms the shore lines of the whole of the Atlantic, of the Indian and Arctic Oceans. Only the Pacific Ocean and parts of the Mediterranean Sea are on the Pacific type. Accordingly, the long eastern coast of Australia is on the Pacific type; the trend of its mountain ranges and the strike of its rocks run parallel to the shores.

C. The Victorian Coast Types.

A map of Victoria shows that the coast consists of three divisions, which may be regarded as the three Victorian Bights. The first bight, which we may call the **Western Bight**, extends from Nelson on the border of South Australia to Cape Otway. This section includes the eastern part of Discovery Bay, which trends south eastward to the Portland Promontory, with its three Capes, Bridgewater, Nelson, and Grant. Then follows Portland Bay, between Portland and Port Fairy. Eastward, again, is the Bay of Warrnambool and Port Campbell, and the long western shore of the Otway Ranges.

The second bight extends from Cape Otway to Wilson's Promontory. The middle part is occupied by the broad King's Bay, and we may therefore call it **King's Bight.** This section of the coast is the most irregular: it begins with high cliffs trending north-east; after passing the high dunes of the Barwon Heads, it turns east and passes the two bold

headlands of Point Lonsdale and Point Nepean, which guard the entrance to Port Phillip Bay. The coast then bends south-east to Cape Schanck. Then follow the two entrances to Western Port, separated

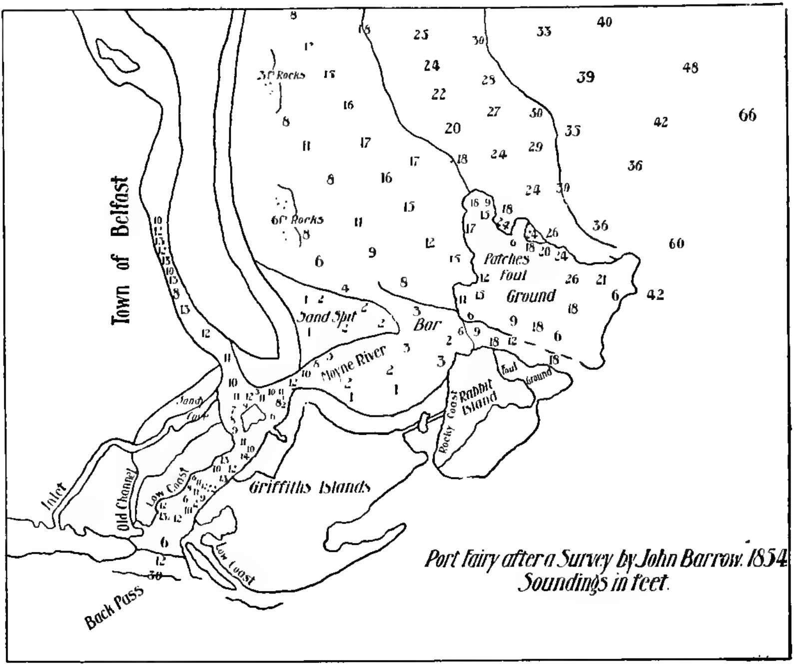


Fig. 13.—Chart of Port Fairy.

by Phillip Island. Passing Cape Paterson and the narrow entrance to Anderson's Inlet, we come to Cape Liptrap, and crossing Waratah Bay, reach the end of King's Bight at Wilson's Promontory. The cape at the end of Wilson's Promontory is the most southern point on the mainland of Australia.

East of it the coast turns north again, and, passing the entrance to Corner Inlet, begins the long, bold curve of the Ninety Mile Beach. After passing Lakes Entrance, the coast runs due east along eastern Gippsland. At Ram's Head it turns more northerly to Cape Howe. This third section of the coast from Wilson's Promontory to Cape Howe, may be known as the **Gippsland Bight.**

After this topographical sketch of the course of the coast, we may consider its geographical character. At the western end of the State is a broad plain, running inland up the **Valley of the Glenelg,** and covered by sands and other beds with marine shells. It is an old sea floor of recent age that has been lifted above the sea. Its surface is a coastal plain. East of the basin of the Glenelg and Portland Peninsula is the basin of the **Eumerella River.** The country here also is composed of comparatively recent marine deposits, which further inland are covered by sheets of basalt. The coast is generally low, and it is indented by a series of harbours—Port Fairy, Port Campbell, and Warrnambool. The form of each is exactly what would result from the flooding of the lower part of a valley. They are in fact drowned valleys. They result from a subsidence of the land, instead of an elevation of the land, such as has happened further west, in the basin of the Glenelg. After passing Port Ronald, at the mouth of the Gellibrand River, we come to the bold headland of Cape Otway, the southern point of the **Otway Ranges.** These hills are formed of carbonaceous sandstones; the strike of the rocks is east and west, and, as the coast runs to the south-east on one side of Cape

Fig. 14.—Rock Stacks near Princetown, formed by the wearing back of a Coastal Plain.

Otway, and to the north-east on the other, the trend of the coast line and the strike of the rocks are divergent.

The shore line along the Otway Ranges consists of steep cliffs, formed by the cutting back of hills of carbonaceous sandstone,* while some of the harder blocks stand out as stacks and islets. These were once the haunts of seals, in the chase of which the first temporary settlements were made along the

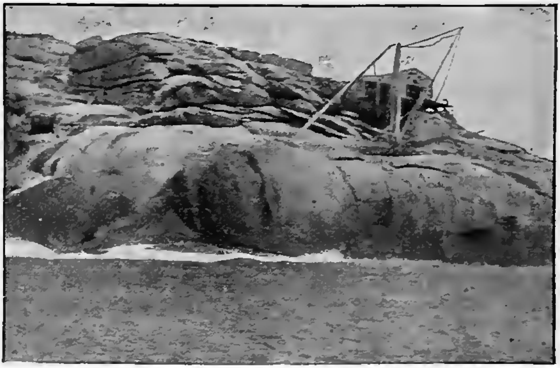


Fig. 15.—Landing Place on Cliffy Island—one of the fragments of the Bnnurong Range.

coast. The seaward valleys form picturesque coves, such as Apollo Bay and Lorne.

East of Cape Otway, the coast continues for some time of the same character. After leaving the carbonaceous rocks, there is another old coast plain, formed of marine limestones and sandstones. These rocks were deposited on the sloping sea floor, at the time of the last submergence of the Victorian coastlands. Near the mouth of the Barwon River these

*[The rocks are not true sandstones, but mudstones; they are called carbonaceous because in some places they contain coal.]

Fig. 16.—Fishermen's Steps, Spring Creek—a Coastal Plain.
(The cliffs consist of beds of sand, clay, &c., with marine fossils.)

deposits are interrupted by a line of sand dunes and recent alluvium. The sand dunes occur from the Barwon Heads to Point Lonsdale. On the eastern side of the entrance to Port Phillip, they form the Sorrento Peninsula, from Point Nepean to Cape Schanck.

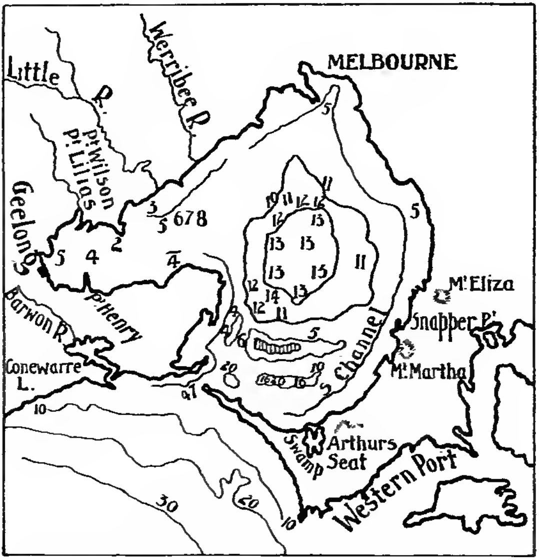


Fig. 17.—Sketch Chart of Port Phillip. (Depths in fathoms.)

Port Phillip is essentially a part of King's Bight, and was at one time connected with it by a wide mouth stretching from the western bank of the Barwon River to Cape Schanck. Port Phillip is a shallow basin, sinking in the centre to a depth of about 80 feet. On the southern side, a little distance off the shore between Sorrento and Dromana, there is a deep trench concentric with the main basin. This trench is in places 120 feet deep; between it and the


Fig. 18.—Eastern Entrance to Western Port Bay from Phillip Island.

entrance is another short deep depression not more than 120 feet in depth. Outside the harbour mouth, is a long flat-topped bank, only 60 feet in depth. Then the floor sinks rapidly, in a steady slope from the shore, to the depth of 120 and 180 feet. There is one break in this slope; it is opposite Sorrento, where the 120 feet line runs in shoreward, as if there had been a river outlet from Port Phillip at this point.

The probable history of Port Phillip is that, like the western harbours, the port was once an old river valley, flanked by wide plains; then the area subsided, the river was first formed into an estuary, and then the lowlands were flooded by the sea. The drifting of heavy sands, by the current from the west, then built up a series of sand dunes across the harbour; the mouth was thus restricted to its present narrow channel, while an earlier accumulation of sand formed the shoals that now separate the central basins from the southern trench.

At **Cape Schanck** we pass from the low sand dune country to a high plateau, capped by basalt, with kainozoic marine deposits. This plateau once extended further west but was cut off by the subsidence that formed Port Phillip. East of this plateau is Western Port, another drowned valley; it has two entrances, one on each side of Phillip Island, which nearly blocks the mouth of the estuary. The shores of Phillip Island are low cliffs; the island is formed mostly of gently rounded hills of old basalt; at its eastern end, a line of high sand dunes connects the main part of the island to the bold headland of Woollamai. This promontory is a mass of granitic rocks, which are not found along the coast of Victoria

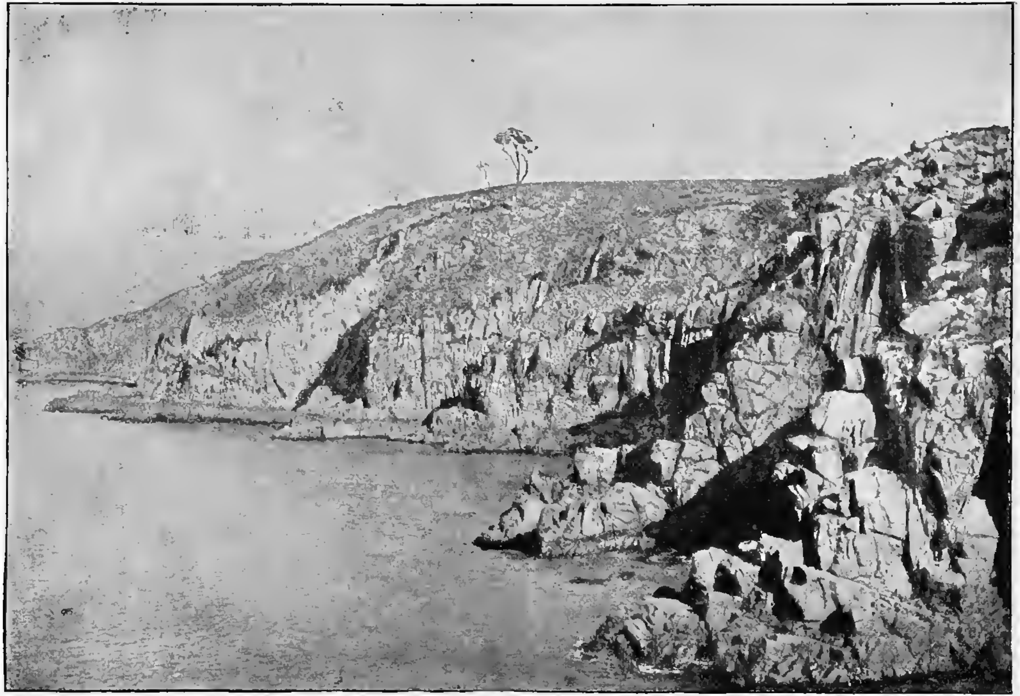


Fig. 19.—Columnar Granite: Cape Woollamai.

further to the west. This granite headland must be regarded as one of the central masses of a now broken up mountain range. Other masses of the same character occur further east, as Wilson's Promontory, Cliffy Island, Cape Everard, and Gabo Island.

The remainder of King's Bight, east of Cape Woollamai, is occupied in part by the carbonaceous or coal-bearing rocks of Kilcunda and Cape Paterson. Beyond Anderson's Inlet is the low level promontory of Cape Liptrap; there we may recognize the influence of the southern mountain chain, in the easterly and westerly trend of the limestones and other old rocks exposed there. They include the oldest rocks on the coast of Victoria. Crossing Waratah Bay, we come to the eastern boundary of King's Bight, the picturesque granitic peninsula of **Wilson's Promontory.** It represents another of the granitic nuclei of the southern mountain chain.

The eastern shore of Wilson's Promontory is the beginning of Gippsland Bight. The Promontory is nearly separated from the mainland by Corner Inlet, a drowned river valley on the northern edge of the granitic mass. East of Corner Inlet begins the **Ninety Mile Beach,** a line 92 miles long, of low recent sand dunes, which now separate the Gippsland lakes from the sea. As we shall see later, this part of the coast represents an old estuary, of which the mouth was closed by a bar of sand dunes, formed by the current along the southern coast drifting material from west to east. The estuary was slowly filled up; the lakes are all that remain of it; and all the rivers that once entered the estuary independently, now have one common outlet to the

sea. The sand dunes of the Ninety Mile Beach end at the Red Bluff, beyond which is Lake Tyers, the estuary of Boggy Creek. That estuary is now generally cut off completely from the sea as a lake; but the level of the water rises, till it bursts through its bar and discharges to the sea. The barrier is then repaired by the drift of sand along the shore. Behind the recent sand dunes along this part of the coast, there is a band of coast plain, similar to that which occurs in western Victoria, behind Portland. It extends from ten to twenty miles inland; it is a belt of sandy country covered by thin forest, and it gradually rises to the height of about 250 feet. The surface was no doubt once a plain which rose slowly inland; but most of the old surface has been destroyed by the rivers, which have cut their valleys through the coast plain almost to the level of the sea.

In the eastern province of Croajingolong, the coast plain narrows and finally disappears. It is replaced by a coast of old rocks and granites with steep cliffs, faced by huge accumulations of sand, piled against the cliffs. In eastern Croajingolong the shore cuts across the southern end of the mountains of eastern Australia; and the coast lands consist of a succession of bold granite promontories and wide valleys. The latter are occupied by estuaries; their mouths, unfortunately for their commercial value, are crossed by sand bars, due to the same action as that which formed the Ninety Mile Beach. The most important of these estuaries are Sydenham and Mallacoota, which represent drowned river valleys, like those of western Victoria.

Summarising the coast characters of Victoria, we see that they are extremely variable. First, the materials are very different. In some places the coast is formed of blocks of hard rock left by the wearing away of the softer rocks, such as Wilson's Promontory and Cape Woollamai. Elsewhere it consists of cliffs and carbonaceous sandstone that are being slowly cut back by the sea, as along the Otway coast. Elsewhere, as at the Sorrento Peninsula, the coastlands are sand dunes made of material drifted along the shore by the ocean current, and piled up by the wind.

Secondly, the direction of the coast is independent of the arrangement of the rocks. The strike of the rocks may, in places, be parallel to the general trend of the shore; but it is generally divergent. The rocks are always so arranged that there can be no question that the strike of the rocks and the course of the coast are not due to the same cause. Thus, in eastern Croajingolong, for example, the strike of the rocks and the trend of the mountain ranges are at right angles to the coast.

The Victorian coast is, therefore, in all respects a coast of the **Atlantic type,** and it meets the Pacific coast type at Cape Howe. Considering then the causes, which lead to the formation of the Atlantic coast type, we may infer that the coast line of Victoria has been formed by subsidences, lowering the area to the south. Bass Strait is a sunken channel. Evidence of this fact is given by various lines of evidence. Proof of a former land connection across the straits is given by the identity of the native animals and plants in southern Victoria and Tasmania.

Mr. Howitt maintains that this land filled up Bass Strait till such a recent date, that the Tasmanian aborigines crossed before the severance of the connection. The Tasmanians had no idea of boats; their canoes were only bent basin-shaped strips of bark, in which it would hardly have been possible to cross the 80 miles of sea between Wilson's Promontory and Tasmania, even had they used the islands in the strait. Mr. Howitt argues that it is improbable that people who once used boats should have completely lost all knowledge of them. He considers, therefore, that the Tasmanians must have crossed by an isthmus over the site of Bass Strait. The Strait is comparatively shallow, ranging from 180 to 350 feet deep; whereas off western Victoria the sea floor rapidly sinks to the depth of over 6000 feet.

At whatever date the Strait was formed, it must have been formed by the foundering of a strip of the earth's crust, long after the development of the great folds in the rocks of the adjacent lands. The subsidences that made the Strait are perhaps even still in progress. That the earth below the Strait has not yet reached a state of equilibrium is shown by the earthquakes which occasionally disturb southern Victoria. The available evidence about these earthquakes shows that most of them are caused below Bass Strait by slight movements of the floor.

Chapter II.—LAND FORMS.

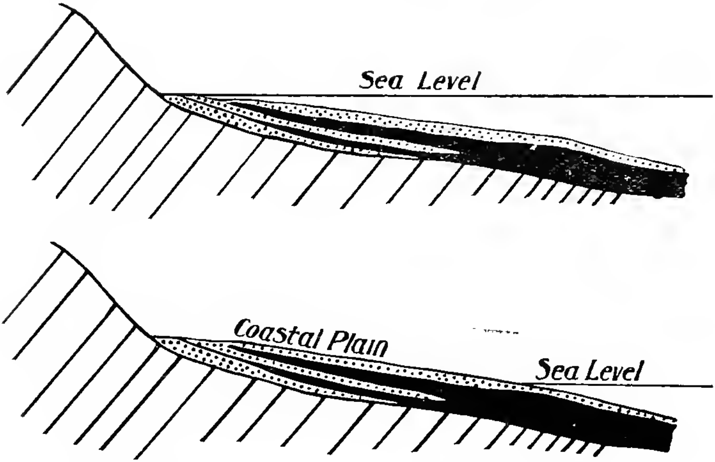
The general structure of a country can be best understood when it is regarded as made up of a number of geographical elements known as "**land forms.**" These land forms may be divided into two classes : — (1) Positive land forms, the solid constituents of the earth's crust ; (2) Negative land forms, the gaps and breaks in the surface of the positive elements.

A country is built up of plains, plateaus, and hills or mountains, or the worn remains of those land forms ; between them occur the negative elements—valleys and basins.

Positive Land forms :—

(a) Plains.—Plains are areas with a broad, smooth surface, occurring at a comparatively low elevation, or else occupying land which is low in reference to the surrounding country. Young plains have smooth unbroken surfaces ; old plains have had their original surface destroyed by the formation of valleys and basins. There are three chief varieties of plains :— (1) **Coastal plains** in which the level surface was part of the bed of an old sea (Figs. 20 and 21) ; (2) **Plains of Marine denudation,** such as a shore platform, which is due to the planing down of a coast to the lower limit of surf action (Fig. 22) ; (3) **Pene-plains,** due to the planing down of a country by river action (Fig. 23). The surfaces of these three plains are due in the first case to **deposition,** in the two other cases to **denudation.**

(*b*) Plateaus.—Plateaus may be regarded as plains raised to a considerable height above sea level, or else raised above the level of the surrounding country. It is comparatively rare to find them with a surface still level; for, as soon as a plateau is elevated, it is



Figs. 20 and 21.—Diagram illustrating formation of a Coastal Plain.

Fig. 23.—Section across a Pene-plain.

attacked by rivers, which cut gorges and valleys through it, and thus destroy the original surface. Young plateaus, however, may retain their old surface unbroken (see Fig. 27, p. 63).

(*c*) Mountains and Hills.—A hill is a mass of material rising above the level of the surrounding country, and culminating in a well-marked crest or

summit. A mountain is simply a big hill. Mountains may occur singly as isolated **peaks**; or several mountains may be grouped together into a **mountain range**; and several ranges may be united to form a **mountain chain**; when several chains are connected by some common features, they form a **mountain system**. Mountains may be formed by the folding of the beds of the earth's crust (**fold** mountains); by the uplift of blocks of material (**block** mountains); by the piling up of volcanic materials (**volcanic cones**); or they may be ridges or blocks left by the destruction of a plateau (**residual mountains** and **buttes**) (Fig. 24). Hill lines are sometimes formed of accumulations of glacial deposits (**moraine hills**). Some authors

Fig. 22.—Plain of Marine Denudation at Cape Patterson.

Fig. 24.—A Butte of Middle Devonian Limestone on the Murrindal River

do not regard buttes, residual ridges, volcanoes, or moraine hills, whatever their size may be, as true mountains, limiting the term to elevations formed by fold and block mountains. **Highlands**—Highlands are areas of high, rugged country, formed by the wearing down of old mountain ranges (Fig. 25).

Mountains, plateaus, and highlands are bounded by **slopes**, which may be either long, curved slopes due to denudation, or cliffs and **scarps**, formed either by the wearing of the base of a cliff, or by a direct earth movement. A range of mountains made up of bedded materials, which have been tilted from their originally horizontal position, is generally bounded by a long

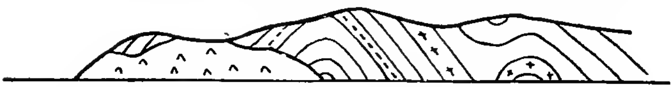


Fig. 25.—Section across Highlands.

dip slope on one side, and a short steep **escarpment** on the other. The dip slope is more or less parallel to the bedding of the strata; the escarpment cuts across the bedding, generally at a high angle (see Fig. 31, p. 70).

NEGATIVE LAND FORMS.—The hollows and depressions that occur in the surface of the solid materials in the earth's crust may be grouped as valleys and basins. A **valley** consists of two slopes, meeting in a central line (the thalweg); each slope is bounded on its upper edge by the water-shed. Valleys may run down to the sea with a long continuous gradient, passing into an estuary which deepens steadily to the sea. Such estuaries are known as **rias**; (e.g. Bantry Bay or Port Campbell). Or a

valley may be divided by transverse barriers into a series of **basins.** If these basins occur in an arid region, the basin may be dry, and in that case it will be a true basin, being completely surrounded by a ring of rocks. In regions of heavy rainfall, however, water will collect in the basin and form a **lake.** The level of the lake will gradually rise, until it reaches the lowest point of the rim; the water will overflow at this point, and the outlet will be cut down, till the lake is drained and its basin left as an expansion of a valley.

A barrier across a deep narrow valley at its junction with the sea, converts the estuary into a **fiord,** such as Mallacoota. Such fiords contain deep water, separated from the sea by a strip of land, a shoal or a bar (Fig. 13, p. 39).

A flat floored basin, which is very large in proportion to the height of the hill line of its rim, may be regarded as a plain encircled by hills.

Chapter III.—THE MOUNTAINS OF VICTORIA.

The general idea of the mountain system of Victoria, expressed in our maps and literature, is that it consists of a "Great Dividing Range" running across the state from east to west, sending off spurs northward and southward. It has, however, been maintained that the chief mountain range of Victoria runs north and south across the eastern part of the State, and that what is called the Great Dividing

Range is only a long spur. Before we can settle this question, we must agree as to the definition of the terms.

What is a mountain? According to Johnson's Dictionary a mountain is 'a large hill, a vast protuberance of the earth.' Webster defines it as 'a large mass of earth and rock rising above the common level of the earth or adjacent land; earth and rock forming an isolated peak or a ridge; an eminence higher than a hill.' The Century Dictionary defines a mountain as 'an elevation of land of considerable dimensions rising more or less abruptly above the surrounding or adjacent region.' There is nothing precise about these definitions, which do not distinguish a mountain from either a plateau or a swelling of the land without any perceptible summit, of which the highest point may be determinable only by refined methods of surveying. In popular terms, a mountain is a big hill; and though this is very indefinite, it is not more indefinite than are the distinctions between allied geographical forms in nature. As a boy, I was told that a mountain was anything over 1000 feet; and this definition has considerable vogue in England; but Stormonth's Dictionary fixes this conventional limit at about 2000 ft. A mountain, according to it, is "a very high hill, usually applied to heights of nearly and above 2000 ft."

Any such numerical limit is unsatisfactory, and we may define a mountain as follows:—A **mountain** is a mass of rock or rocks* rising to a considerable

[*Geologically soil and loose earth are considered rocks.]

elevation above the surrounding country, and culminating in one or more well marked summits or crests. The vaguest point in this definition is that the amount of the elevation is left undefined; but no precise limit can be stated. The height must be taken in conjunction with the area and elevation of the surrounding country.

The real difference between a hill and a mountain is psychological; it is a matter of the impression left by an elevation on the mind of the observer. A rugged rock-mass, rising like the You-yangs from a broad plain, has all the impressiveness of a true mountain; whereas the same mass situated close to an Alpine chain, would be an insignificant foot hill. A smoothly rounded down may slowly rise to 5000 ft. above the sea, and yet have none of the attributes of a mountain.

The above definition separates a mountain from a **hill** only by its size, from a **plateau** by its possessing a well marked summit or crest. A **peak** is a single sharp summit, and may be either the highest or a subsidiary point on a mountain.

Mountains rarely occur singly, but generally as series of mountains, forming **ranges**. Here again the popular term is unsatisfactory. The Century Dictionary defines a mountain range as "a line or chain of mountains." The Standard Dictionary, on the other hand, sharply separates the meaning of the terms "range" and "chain," a range including more than one mountain, but less than a mountain chain. It tells us that a chain is, in strict scientific usage, "an aggregate of ranges formed at different times, yet holding a common geographical relation; a

polygenetic series of associated mountains." It also defines a mountain range as "strictly one of the component portions of a mountain chain, formed by a single orogenetic movement (monogenetic)."

It is convenient to accept this definition, which has been widely adopted by geographers; but it has not the same precision as the French word "Chainons" for one of the constituent parts of a complex mountain system. We may then define a **mountain range** as a line or group of mountains formed by one cause, such as a series of earth movements, and a **mountain chain** as a connected series of mountain ranges. This connection need not imply identity of age; for the formation of a mountain chain is a long and slow undertaking. Nor does it necessarily imply similarity in materials; for the same mountain-making forces act upon materials of different kinds. Nor does it necessarily imply similarity in geological structure: for the structure of a mountain chain will vary according to the toughness of the rocks affected by the mountain-making forces. But it does imply that the chain is due to forces of elevation or depression, which derived their power from the same great cause, for example, the sinking of an adjacent ocean bed or the crumpling of part of the earth's crust. This unity of cause gives all the mountains in a mountain range, or all the ranges in a mountain chain, a definite community of origin.

We can now more profitably enquire as to the classification of the mountain system of Victoria, and the nature of its "**Great Dividing Range.**" Sir Thomas Mitchell, who, in 1836, crossed the line thus named, was a first-rate geographer. He named

many of the mountains in Victoria—the Grampians, Pyrenees, Mounts Alexander and Macedon; but, neither in the narratives of his travels, nor in his text-book of the geography of Australia, does he make any suggestion of the existence of the "Great Dividing Range." Nor is this range mentioned by Westgarth in his earlier books upon Victoria, nor by Haydon in his "Australia Felix." So far as I have been able to discover, the first use of the name the "Great Dividing Range" in popular literature is in Bonwick's "Geography of Australia and New Zealand (p. 92), of which the third edition was published in 1858. But the name had been previously adopted in the official definition of county boundaries. Thus it was used in a proclamation of the 29th December, 1848, which was published in the Government Gazette of the 10th January, 1849 (p. 12).* After 1858 the name came rapidly into use; for all the early prospectors knew to their cost, that there is a line of highlands separating the basin of the Murray from the southern lowlands of Victoria.

The existence of the Main Dividing Range was not accepted without protest. The chief objections to it were raised by Brough Smyth.† He argued that the main mountain chain of eastern Victoria is the southward continuation of the "main Cordillera" of eastern Australia. This line passes from the frontier of New South Wales to St. Clair, and then continues southward, crossing the main Gippsland Valley by the pass at Drouin, and passing through Wilson's Promontory to Tasmania. The

* For this reference to the first use of the term by the Lands Department I am indebted to the courtesy of Mr. T. F. Morkham, the Secretary for Lands.

† The Gold Fields and Mineral Districts of Victoria—Melbourne, 1869, p. 10.

line from St. Clair westward across Victoria to the Grampians, Brough Smyth called the Great Spur. Murray, on the other hand, in his admirable book on the "Geology and Physical Geography of Victoria" reverses this nomenclature. He maintains that the main mountain line runs east and west across Victoria, and is what Smyth called the Great Spur.

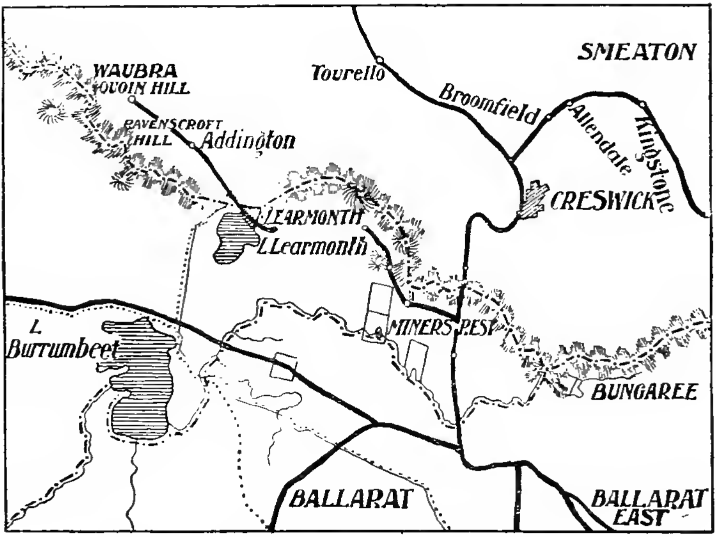


Fig. 26.—The Great Dividing Range near Ballarat, according to the Map of the Surveyor-General.

Smyth's main chain was Murray's Southern Spur. The term Great Dividing Range, thus supported by Murray, has been almost universally accepted. The official maps of Victoria represent the main watershed as a continuous, well-defined mountain range; they mark it as such, even where on the field there is nothing but a level flat. Fig. 26 is a copy of part

of the official map of Victoria, by Skene, showing the Dividing Range near Ballarat; the hill shading shows a narrow, sharply-defined mountain range. The accompanying photograph (Fig. 27) shows an actual view of the country; it is a level basalt plain, and, if several men were sent across it independently to put a mark upon the highest point, they would probably differ in their positions by about a quarter of a mile.

Fig. 27.—Photograph of the "Great Dividing Range" north of Ballarat. The actual Divide—eight miles to the north of Ballarat. The farm-house in the foreground is situated on the northern slope of the Divide. The situation of the camera is on the southern slope.

The popular belief in this Main Dividing Range has influenced biologists; and they have supported geographers by the statement that biological evidence shows that this dividing range was established at a far distant period, and has maintained its position throughout the later history of Victoria.

The evidence most generally cited in this connection is the absence of eels from the upper

tributaries of the Murray, although they are found in the rivers that flow southward from the Divide; but I have been assured by fishermen that eels are occasionally found in the tributaries of the Murray. They no doubt sometimes wriggle their way across the Divide from the southern streams. The rarity of eels in the Murray can very easily be explained, as it is now known that eels breed only in the sea. Their scarcity in the upper Murray may be due either to the difficulty of entrance to the Murray from the sea, or to the fact that the eels do not work their way as far as the upper waters. Other evidence has been quoted from the distribution of birds; thus J. A. Campbell* has pointed out that the Divide forms the boundary between the white-back and black-back magpies; but he himself quotes the white-backs as occurring north of Castlemaine.

The general zoological and botanical evidence gives no support to the idea that the Divide is an important dividing line in the distribution of animals or plants.

In spite of geographers and biologists, I venture to maintain that the Great Dividing Range is a misleading, geographical myth. Let us compare its structure with some typical mountain ranges. The **Alps** are formed of a great series of granite masses, surrounded by a zone of rocks, which have been altered from their original state by the former heat of the granites; outside these rocks, again, is a layer of stratified rocks of many different dates. Mont Blanc, for example (Fig. 28), shows this structure in a simple

* "The Gymnorhinae, or Australian Magpies, with a description of a new species." Proc. Roy. Soc., Vict., Vol. VII. (N.S.), 1895, p. 205.

form. It is a great central block of granite, surrounded by altered rocks (known as schists), and flanked by ridges of sedimentary rocks, which have been raised by the intrusion of the Mont Blanc granites. Mont Blanc and its subordinate mountains, are, therefore, grouped together as the Mont Blanc Range. Running across Switzerland we have a series of smaller granite masses, with their associated secondary peaks; the whole of this series of mountain ranges forms the Alpine Chain. The Carpathians, the Caucasus, and the Himalaya to the east of the

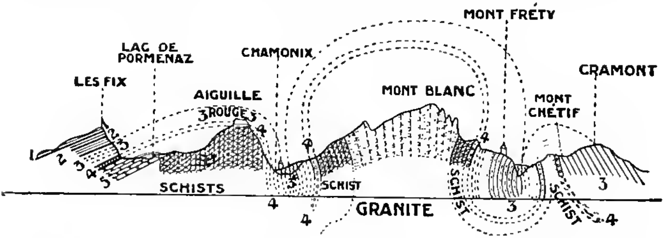


Fig. 28.—Section across the Mont Blanc Range, a type of Alpine mountains.

Alps, and the Pyrenees to the west, have the same type of structure; they were all formed by intense pressure, which has crushed the rocks into slates and schists, and thrown the stratified rocks into violent folds: they were all formed at about the same time as the Alps. These mountain chains may be grouped together as the Alpine System.

Take again the **Andes**; this mountain chain runs throughout the whole length of South America. It consists of three parallel series of ranges. On the west are the Coast-Cordillera, composed of comparatively low ranges of extremely ancient rocks; in the middle is the line of the Main Cordillera,

including the highest summits in the Andes, which are mostly formed of recent volcanic cones. East of the Cordillera there are stratified rocks, which pass eastward below the great eastern plains. The whole chain of the Andes has, no doubt, been formed by lateral thrusts from the west, by displacements and volcanic eruptions due to the subsidence of the floor of the Pacific.

The **Pennine** Range in England represents another type of mountain structure; it consists of a series of blocks of limestone and shale, which have been broken out of once continuous sheets, by a

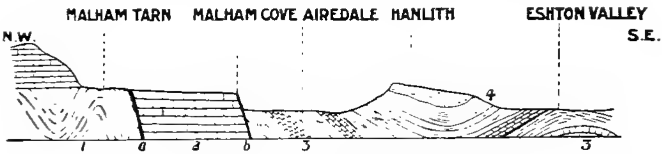


Fig. 29.—Section of the Pennine Range, England, illustrating the structure of the Pennine type of Mountains—*a*, *b* Faults.

series of fractures known as faults; the blocks have been raised most at the western edge, so that they present a steep face to the west, and long gradual slopes towards the east (Fig. 29). The chief summits of the Pennines are single mountains; but the whole series of uptilted blocks of limestone forms the Pennine Range.

Now, let us proceed to consider the characters of what is called the Great Dividing Range of Victoria. It begins on the west with the **Grampians,** which consist of ridges and blocks of old sandstones. Ridges, folds, and faults all run north and south. The ridges are made partly by gentle folds caused by pressure from east and west, and in part by faults.

There is a unity about the structure of the Grampians, which entitles them to rank as a true mountain range, and it is a range of the Pennine type. East of the Grampians the "Dividing Range" crosses a band of slates and sandstones, which are much older than the Grampian sandstones. These beds have been bent into numerous sharp folds, which, in their intensity, often remind us of the folds on the flanks of the Alps. But these folds, unlike those of the Alps, are at right angles to the "Dividing Range," and are quite indifferent to its course. The structure of this part of the "Dividing Range" is different from the Grampians, both in the character and arrangement of the rocks. The "Dividing Range" here is a ridge left by recent denudation; it is later in date, and quite independent of the forces that produced the folds in its constituent rocks. Near Ballarat the "Great Dividing Range" is a level basalt plain, forming in places an imperceptible divide; it is a mere watershed, dividing the waters of the Loddon and the Yarrowee. Eastward, again, the "Great Dividing Range" runs along the crest of Mount Macedon, which is the worn-down stump of an extinct volcano. It suddenly leaves this crest, and strikes north across some slates and basalts on to a ridge of granite. It follows this ridge eastward, and crosses more slates, again at right angles to their strike. It continues across the valley at East Kilmore, which is followed by the main road to Sydney, and along the line of the Hume Range and the Yarra track. The Divide here crosses what was once a great plateau; the rivers have cut their valleys deep into this plateau, leaving the ground between as ridges. The Divide here runs

along the crest of one of these residual ridges, and along one some distance down the southern slope of the old plateau ; the Divide, in fact, is lower than the outlying peaks to the north.

Passing further to the east, we have still other types of structure ; but we have followed the Dividing Range far enough to see that it is composed of rocks of many different ages and characters—(ordovician, silurian, and upper palaeozoic sediments ; lower cainozoic volcanic rocks and upper cainozoic basaltic plains) ; and that parts of the Dividing Range are of altogether different structure, and have been formed by independent agencies and disconnected earth-movements.

The "Great Dividing Range" is in fact only a watershed. A watershed is simply a water-parting, or a line of separation of waters, which flow into different basins. The term is simply a translation of the German term wasserscheide — a water separation. And this is all the so-called "Great Dividing Range" can claim to be.

Mountains Trending North and South.

Having thus dismissed the "Great Dividing Range," we must enquire what true mountain ranges there are in the state. The true mountain ranges of Victoria include, in the first place, a series of ranges which run north and south. They may be divided into four groups. The first group includes some ridges formed of the oldest known sandstones (now altered to quartzites) in Victoria, with some igneous rocks known as diabase. One of them forms **Mount Stavelly**, a fragment of a range, of which two other

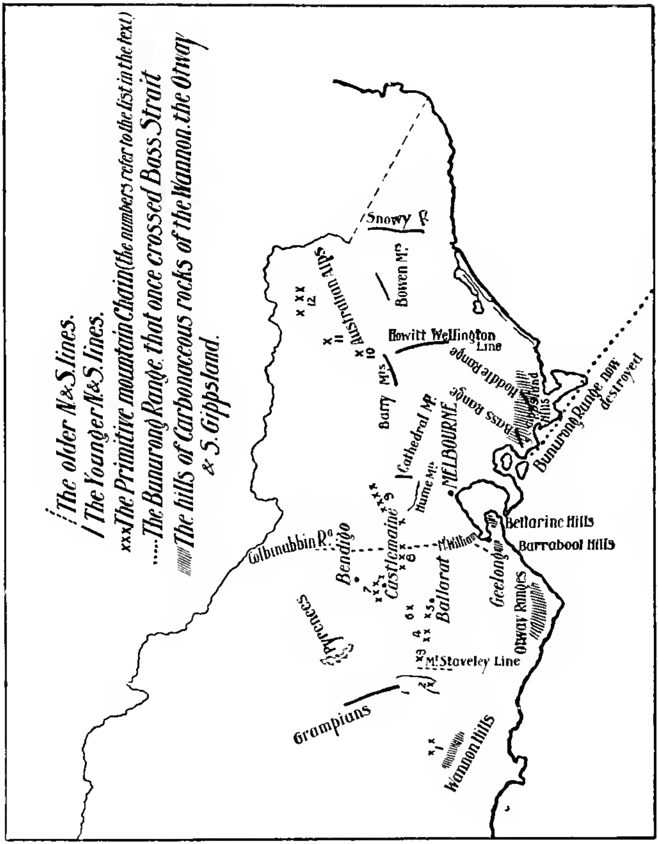


Fig. 30.—The chief Mountain Lines of Victoria.

disconnected outlyers are now preserved further to the north. The best-known member of the same group forms the range of **Mount William** near Lancefield, and the **Colbinabbin Range,** which runs from Heathcote through Mt. Camel and Mt. Pleasant, until it dips below the Murray Flats, north of the road from Rushworth to Elmore. The Mt. William Range consists of similar rocks which run from Lancefield Gap northward to Mt. William; it was probably once continuous with the Colbinabbin Range.

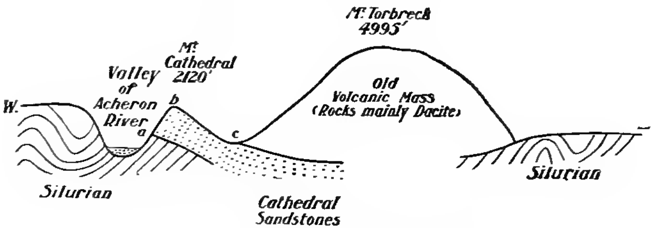


Fig. 31.—Section across the Cathedral Range.

The second group of the ranges trending from north to south is formed of upper palaeozoic sandstones, which have been thrown into gentle folds by pressure from the east and west. This group includes (1) the **Grampians,** which run west of Stawell from Mt. Zero to Dunkeld; the southern part of this range is so jagged that it is called the Sierra Range: to the west of the main range of the Grampians are the two parallel and similar Victoria and Black Ranges. (2) The **Cathedral Range** (Figs. 31 and 32) near Buxton, in the valley of the Acheron. (3) A long line of sandstone hills running southward from **Mt. Howitt** and **Mt. Wellington** to the main Gippsland valley.

A fourth north-and-south range, which may be placed in this group, occurs along the Snowy River; its rocks are known as the **Snowy River Porphyries,** and they probably occupy the site of a chain of old volcanoes, that were in eruption before the deposition of the Grampian sandstones.

Fig. 32.—The Cathedral Range.

Mountains Trending East and West.

The remaining Victorian mountains have a general trend from east to west; they may be divided into four groups. The first of these are ridges of rock left by the dissection of a plateau, of which they once formed a part. These residual ridges include the Bowen Mountains, the Hume Mountains, the Barry

Mountains, and many of the best known ranges in central Victoria.

The second group is in southern Victoria; it consists of the **Otway Ranges** and the **mountains of southern Gippsland**, which agree in their chief characters; they are composed of feldspathic sandstones, or rather mudstones, which strike from east to west, and have a prevalent dip to the north. The rocks often contain logs of fossil wood and leaves of land plants, and some valuable coal seams. These hills may be regarded as all part of a once continuous mountain chain, which has now been broken by denudation into five fragments :—the Wannon Hills, the Otway Ranges, the Barrabool Hills, Bellarine Hills, and the South Gippsland Hills. Various spurs and ridges in the South Gippsland Hills receive local names, of which the most important are the Bass Range for the hills between San Remo and Outtrim, and the Hoddle Range for the hills that run north-east from the west end of Corner Inlet.

The next group of mouutains is the most important in Victoria. It forms the **mountain backbone of the state.** The mountains consist of a series of granitic masses (or, as they are technically called, massifs); in most cases, each of them is surrounded by a thin zone of baked sedimentary rocks. The essential rock is a member of that group of rocks, of which granite is the most typical representative. They may therefore be called granitic; but they are rarely true granites.* These rocks are of igneous origin; that is, they have been formed by the action of intense heat, and they

* The most convenient general name to give these rocks is that of granodiorite; for they are intermediate in character between true granites and diorite; in places there are patches of granite and some of diorite.

have solidified from a molten state. They were formed at great depths below the earth's surface; and before they were exposed by denudation, were covered by a vast thickness of such rocks as sandstones, clays, and slates.

The characters, which the mountains of this series have in common, are as follows:—they consist of great masses of granitic rocks, which were forced, in a molten state, into the older beds of shale and sandstone; at least most of them were formed at the same time (Devonian); and their general trend is west and east, cutting across the trend of the older rocks, which generally strike from north to south.

The extent of this mountain chain is not yet fully determined; for the age of all the granitic masses has not been finally settled. The granites of Dundas and Benambra, and perhaps also some of the others, may be older than the typical members of this series.

This line of granite masses may be called the **Primitive Mountain Chain** of Victoria: for though there were earlier mountains in this part of Australia, the special development of Victoria was determined by this east and west line of granitic masses. Most of the Primitive Mountain Chain is to the north of the Divide.

This Primitive Mountain Chain of Victoria includes the remains of ten or twelve distinct mountain groups:—

(1) The **Dundas** Highlands in the west of the state, between the Wannon and the upper branch of the Glenelg; it consists of the

granitic masses and old schists about Wando Dale and Nareen.

(2) The granitic mass between the Grampians and the Victoria Range, round the **source of the Glenelg.**

(3) The granitic rocks between **Ararat** and **Moyston.**

(4) East of Ararat are a series of granitic masses belonging to the Primitive Mountain Chain, and forming the **Southern Pyrenees**; they extend from Larne Gerin on the west to Lexton on the east, and include Mt. Buangor, Mt. Cole, Amphitheatre, and Lexton, which may all be grouped together.

(5) Crossing the basalt plain at the head of the Bet-Bet Valley we come to the granitic hills **around Clunes**, including Mt. Bolton, Mt. Misery, and Mt. Beckwith.

(6) Near Clunes the Primitive Mountain Chain takes a sharp bend to the north-east. Its next fragment is the granitic mass of **Rodborough.**

(7) On the eastern side of the Loddon Valley, the Primitive Mountain Axis is conspicuously represented by the granitic range which extends from **Mt. Tarrengower** and the **Harcourt Ranges**, south of Bendigo, through Ravenswood to **Mt. Alexander.** This group ends to the east, in the valley of the Coliban and the Campaspe.

(8) East of these rivers are the **Cobaw** and **Mollison Creek** ranges, which belong to the Primitive Mountain Chain.

(9) The next representative is on the eastern side of the Seymour-Kilmore Valley; it begins with Breach Peak, and continues through the **Strathbogie** ranges into Delatite.

(10) Then follows **Mt. Buffalo.** Here the mountain line has been bent to the north, owing to the resistance of the old crystalline rocks of Bogong.

(11) **Mt. Stanley** is the next member of the Primitive Mountain Chain.

(12) The last group in Victoria is formed by the granites of northern **Benambra**.

The age of the first, the third, and the last three of these twelve granitic masses is doubtful; they may be older than the rest, and belong to an earlier geological system.

These granitic masses are the central deep-seated nuclei of high mountains, which stretched across Victoria as the primitive mountain chain. But this chain is now represented only by the worn stumps of its once lofty peaks. It is now but a subdued mountain range.

In Southern Victoria we have the traces of a **parallel range** having similar characters to those of the Primitive Mountain Chain. It may be called the **Bunurong Range,** after the tribe that lived on the adjacent part of the Victorian coast. It is represented by the granitic masses at Cape Woollamai, Wilson's Promontory, Cliffy Island, Hogan Island, and the Kent Islands. But the earth-movements that formed Bass Strait have shattered this old mountain line; and it now represents the relics of a mountain chain in the last stages of decay.

Relics of still older and more fragmentary mountains occur under the north-eastern plains; but here the granite hills have not only been worn down, but also buried under horizontal layers of sand and clay. The tops of the old mountains are seen only in small isolated patches of old rocks, which now lie flush with the surface of the recent beds, under which the main ridge lies buried.

The broken fragments of former mountain ranges are widely scattered through Victoria. They remind us that mountains are far from being as immortal as some poets say. The hills are raised so high, that they are exposed to the persistent assault of all the levelling forces of Nature. A mountain range that rises above the snow line has, geologically speaking, but a short lease of existence. The images that represent mountains as the symbols of immortality and strength sound false to the geologist. Mountains to him are rather a warning of the weakness of mere bulk, when exposed to the attacks of the unseen, but untiring, forces of change and decay; but they also remind him that these destructive powers cannot work without setting in motion the forces of reconstruction.

Chapter IV.—THE PLATEAUS, BASINS, AND PLAINS.

A.—The Plateaus.

The classification of the mountains of Victoria in the last chapter treated some of the best known of our mountains, such as the Barry, Hume, and Bowen

Mountains, the Pyrenees and the Alps as fragments of old plateaus; while it omitted altogether Mts. Macedon, Buninyong, and Dandenong, as they are not true mountain ranges, but extinct volcanoes. The ridges and spurs left by the denudation of old plateaus must be considered in greater detail.

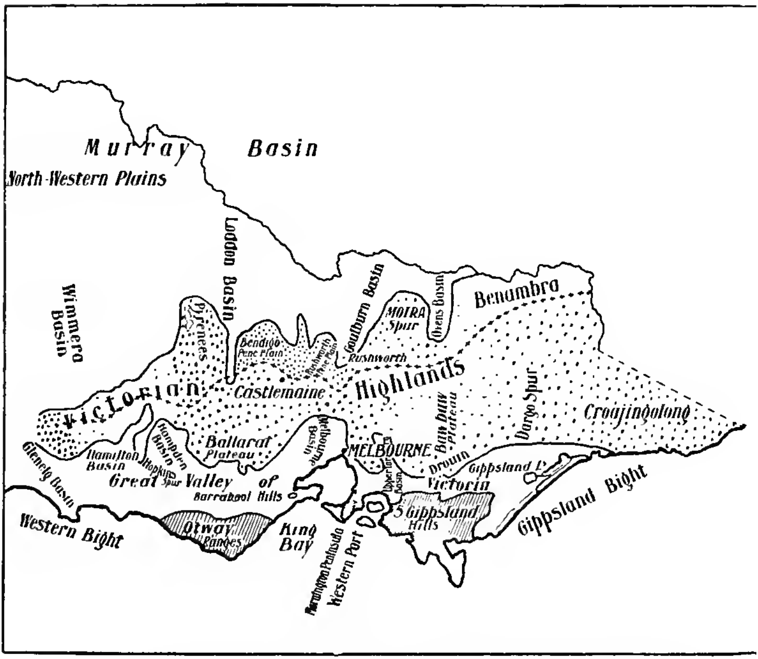


Fig. 33.—Map of Victoria, showing the four chief Geographical Divisions and leading sub-divisions, including Plateaus and Basins.

Most of the mountainous parts of Victoria was once a broad level plateau; but this plateau has been so dissected by river action, that its surface is now only dimly discernible. A young plateau consists

of a block of country with a steep face on one or more sides, and either a horizontal surface or a long gradual slope on another side. The surface of a plateau generally has a slight slope in one direction, down which the drainage runs in narrow gullies. As time goes on, the gullies are deepened into narrow river gorges, which break the surface of the plateau. The strips of the plateaus between these gorges form broad, flat-topped ridges. These ridges, in time, are reduced to narrow spurs, while the gorges are broadened into wide valleys. But the surface of the plateau may still be recognizable, as the spurs reach nearly to its level, and the crests will slope gradually downward with the same slope that the surface of the plateau had (see Fig. 47, p. 107) The continual reduction in the width of these ridges gradually destroys them, and their materials are swept away by the rivers. The ultimate effect of river action is to reduce a country to a plain, having a gradual slope toward the sea.*

Plains due to river erosion are not absolutely level; because the river, which carved them, must have had a slight slope downward to the sea, and the harder bands of rocks would longer resist denudation and decay. Hence Professor Davis has suggested for such a river-cut plain, the name of **pene-plain**; the term means almost a plain, just as peninsula means almost an island.

Victoria is made up of four main **geographical divisions**:—

(1) Running across central Victoria from east to west are the **Victorian Highlands**; they were

* The ultimate slope is estimated at 1 in 50,000, as that is the least slope down which water can carry fine silt.

once a chain of lofty mountains, but have been worn down into the condition of highlands. They occupy nearly the whole width of Victoria in the east, but they taper westward, to a point in the valley of the Glenelg.

(2) South of the Victorian Highlands is the **Great Valley of Victoria.** It begins in the west of the state, where it extends from the foot of the Victorian Highlands to the coast. The southern bank has there been worn away by the advance of the sea, so that the Valley has only one bank. It continues across the valley of the Hopkins River and the basin of Lake Korangamite. The Otway Ranges here form the southern boundary of the Great Valley, which is occupied by the lava flows, lakes, and the rich alluvial plains that extend from Hamilton to the shore of Port Phillip. Port Phillip itself is only a drowned part of the Great Valley. It is continued further to the east by Carrum Swamp, by the line of low country, which reaches the shore of Western Port, and by the Kooweerup Swamp. The Great Valley contracts in Gippsland, till it crosses over a low divide at Drouin, into the valley of the Latrobe, which widens out eastward into the broad alluvial plains opposite the Gippsland Lakes. The Great Valley is here terminated, owing to the northward trend of the coast in the Gippsland Bight.

(3) The fragments of the southern bank of the Great Valley of Victoria are the Otway

Ranges, the Barrabool Hills near Geelong, Arthur's Seat and the highlands of the Mornington Peninsula, and the hills of southern Gippsland. This was, no doubt, at one time, part of a **continuous mountain line**; while the granite masses of Cape Woollamai, Wilson's Promontory, and the islands of Bass Strait continued this mountain line further to the south-east.

(4) The **basin** of the **Murray** River and the north-western plains. This area is bounded to the south by the Victorian Highlands, and extends northward to the Murray River, and westward to the South Australian frontier.

The mountainous parts of Victoria are mainly formed by broad areas of old dissected **pene-plains.*** In the south the Otway Ranges and the southern Gippsland hills were once a great pene-plain, which sloped northward into the Great Valley. The Victorian Highlands consist of the granitic masses of the Primitive Mountain Chain, which is bounded, on either side, by a broad band of pene-plains. The band on the southern side of the Primitive Mountain Chain slopes southward to the Great Valley of Victoria; that on the northern side of the Primitive Mountain Chain slopes northward to the Murray basin. This statement is true only when taken generally, as there are some local exceptions. The main pene-plain is interrupted by depressions, in which the slope is partly in the direction opposite to

*Mr. A. W. Howitt showed that the mountains of Northern Dargo have been formed by the dissection of a plateau, in a paper on "The Geological Structure of Northern Gippsland," Progr. Rep. Geol. Surv., Victoria, No. IV., 1877, p. 115, and Figs. 6 and 7.

Fig. 34.—The Upper Valley of the Parwan River, and the Pene-plain on the eastern part of the Ballarat Plateau.

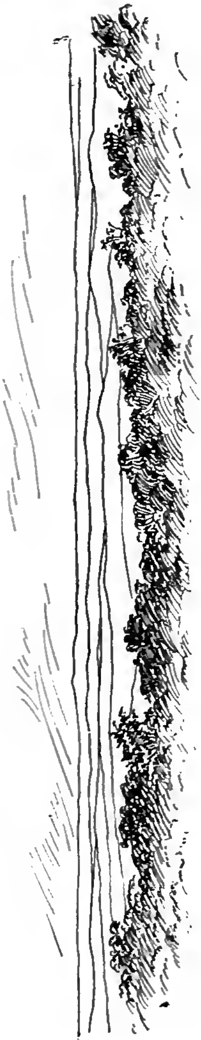


Fig. 35.—View across the Pene-plain of the Victorian Highlands looking south-eastward from Mt. Ida, Heathcote.

that of the main slope of the district. The extent of such local interruptions of the main slopes has not yet been determined, but they are comparatively unimportant. The main pene-plains can be easily recognised by studying the slopes of the principal spurs between the river valleys.

In the south is the old **pene-plain of the Otway and Gippsland Ranges.** It was formed in the main by the cutting down of the carbonaceous rocks. The long northern slope of the headland of Woollamai (Fig. 36) is a relic of part of this pene-plain; and we may recognise part of it at a higher level if we look eastward over the hills about Jumbunna, from the top of the hill to the west of that town.

B.—The Pene-plains of the Victorian Highlands.

The great southern pene-plain sloped northward into the Great Valley of Victoria, north of which is another belt of pene-plains, forming the southern part of the Victorian Highlands. The rocks of these Highlands consist mainly of contorted slates

Fig. 36.—Cape Woollamai, seen across the Eastern Entrance to Western Port.

and sandstones, flanking the granites of the Primitive Mountain Chain.

The line of the Primitive Mountain Chain runs through the Highlands, and separates two pene-plains, one of which slopes to the south, and the other slopes to the north.* In western Victoria the Pyrenees are the remains of the pene-plain, with a long slope northward. In the part of Victoria east of the meridian of Melbourne, the northern slope is short, and the main pene-plain extends from a little south of the North-Eastern railway to the Great Valley.

The two pene-plains occur on the flanks of the Primitive Mountain Chain: both send out a series of spurs, one to the north and the other to the south. The **main southern spurs** are six in number. The first is that of the **Hopkins,** between the Glenelg and the Hopkins Valley. It extends from Glen Thomson, past Chatsworth and Hexham, and is an outlier from the main Highland, near Ararat. The second spur forms the great **Ballarat Plateau,** which extends from near Skipton on the west to Bacchus Marsh; it ends southward in two projections at Rokewood and Steiglitz. The third southern spur forms the **Yarra Plateau.** This pene-plain once ran from the Strathbogie Ranges, across the present main divide between Mt. Disappointment and Mt. Arnold. It forms the old platform under the Dandenongs. The fourth southern spur is that of the **Baw Baw pene-plain;** it includes the highlands on the eastern boundary of the Yarra, the basins of the Thomson and the Aberfeldy, and extends as far east as the Macallister

* The granitic masses of the Primitive Mountain Chain have themselves been planed down until, in places, they form part of the slopes of the flanking pene-plains.

River. The **fifth** southern spur runs from Mt. Buffalo and Mt. Stanley across the Barry Mountains and through Dargo to the Tambo; it ends below the coastal plain between Sarsfield and Bruthen. The **sixth** southern spur occupies much of the surface of Croajingolong.

The northern pene-plain sends off four or five branches to the north; the most important is the **Kara Kara** pene-plain; it has now been dissected into the various spurs and ridges of the Pyrenees. It extends from the Primitive Mountain Chain, northward to St. Arnaud and Wedderburn, beyond which it sinks below the great Murray Flats. To the east of the Loddon Valley is the **Bendigo** pene-plain, which extends as far north as Raywood, as far south as Mandurang, and as far east as the Colbinabbin Range and Heathcote. The third northern pene-plain extends from Puckapunyal Hill to **Rushworth.** The fourth is the broken up pene-plain of **Moira,** which extends from the Strathbogie Ranges nearly to the Murray; but it is so dissected that it is barely recognizable. To these northern series it may be necessary to add the **Benambra Highlands,** which appear to be a greatly dissected pene-plain.

C.—The Basins.

These various pene-plains are separated by a series of basin-shaped depressions and valleys. The pene-plain of the Otway and the Gippsland Ranges is separated from the northern series, by the **Great Valley** of Victoria, which runs from the lower basin of the Glenelg to the great volcanic plains of Villiers and Hampden, and past the Korangamite and Colac

Lake series. The Great Valley also includes the depressions of Port Phillip Bay and the Kooweerup Swamp, and then, crossing the saddle at Drouin, is continued by the Latrobe Valley into the basin of the Gippsland Lakes.

Running north from this great valley are a series of basins between the spurs from the Victorian Highlands. Starting to the west, the first basin is that of the **Glenelg**, which extends from the South Australian border to the carbonaceous rocks of Merino and the old highlands of the Wannon Valley. The second basin is that of **Hamilton**, extending between the carbonaceous rocks at Casterton and the Hopkins pene-plains between Glen Thomson and Chatsworth. The whole of this basin is now covered by basaltic plains. The third basin is that of **Hampden**, which intervenes between the Hopkins pene-plain and the Ballarat plateau. The fourth is the **Melbourne** basin; it includes Port Phillip and the basaltic plains from the scarp of the Ballarat plateau, west of Bacchus Marsh, to the Yarra plateau. Most of the Yarra plateau may be regarded as a shelf on the eastern border of the Melbourne basin, of which the eastern boundary may then be drawn along the ridge through Queenstown, the Christmas Hills, and Mooroolbark. East of this line occurs the fifth basin, that of the **Middle Yarra**, Kooweerup Swamp, and Western Port; they were probably once part of a connected basin. The sixth and the last basin to the east is that now occupied by the **Gippsland Lakes.**

The basins between the spurs from the Victorian Highlands are less well marked on the north than on the south. They all open into the Great Murray

Fig. 37.—Kooweerup Swamp.

Plains. In the west is the basin of the **Wimmera,** between the Grampians and the Pyrenees. The second northern basin is longer and more narrow; it is the basin of the **Loddon,** which occupies the lowlands between the peneplain of Kara Kara and the Bendigo plateau; this basin extends south from Bridgewater past Eddington and Carisbrook to Campbelltown, Clunes, and Creswick. The third basin is that of the **Goulburn,** which occupies the lowland between the Rushworth peneplain on the west, the islands of the Strathbogie country on the south, and the southern part of the Moira

pene-plain on the east. The fourth and last of the northern basins occupies the lower part of the **Ovens** Valley, extending from the Murray to Wangaratta and Tarrawingee.

D.—The Plains.

The existing plains of Victoria occupy nearly one half of its area. They may be divided into four distinct groups. The first is the coastal plain; the second, the plain of the Murray; the third, the alluvial plains of the Gippsland estuaries; the fourth the plains of south western Victoria.

I.—THE COASTAL PLAINS.

A coastal plain may be defined as a plain formed by the uplift of a sea floor. The bottom of the sea, near a coast, is gradually covered by deposits of sand, mud and limestone. The material forms a sheet with a fairly level surface, which has a gradual slope away from the coast. When a sea floor is raised evenly above sea-level, it forms a plain surface sloping slightly towards the sea (Fig. 21, p. 53). Such a plain is a coastal plain, and differs essentially from a pene-plain. For the surface of a coastal plain is determined by deposition, whereas a pene-plain is formed by planing down an undulating tract of country; its rocks are cut down regardless of their structure, as when a saw cuts across the grain of a block of wood (Fig. 23, p. 53).

Most of the southern coast of Victoria has a fringe of coastal plains. Between the Gippsland Lakes and the Snowy River the country consists of comparatively horizontal beds of sand and limestone; these

rocks were formed by deposition beneath the sea, but they now stand above sea level. These beds form a band from 8 to 12 miles in width, extending from the shore to the foot of the old rocks of the Victorian Highlands. The surface of this country represents the old sea floor. The surface slopes seaward as the old sea floor deepened seaward. The original surface has been broken up by a series of northern and southern valleys, in which flow the Snowy River, and the streams, which discharge into the various arms of Lake Tyers and the marshes that line the shore. The valleys are separated by ridges of undulating heath country rising inland to the height of 250 ft.

Another coastal plain showing still less of the original surface occurs to the south of Geelong; it stretches inland, from the coast between Point Flinders and Airey's Inlet, and up the valley of the Moorabool.

The south western corner of Victoria between the Fitzroy River and the Glenelg is probably also a coastal plain; and, if so, it probably once continued inland round the western end of the Victorian Highlands, and then eastward along its northern edge as far as Stawell.

II.—THE NORTH-WESTERN PLAINS.

North-western Victoria, between the northern margin of the Highlands and the Murray, is occupied by a vast expanse of **young plain.** It is a country that at first looks as bare of interest to the geologist as any area could be. A good idea of it can be got by a view from any of the old granite bosses, such as Pyramid Hill or the Terricks, that rise like islands from a vast

sheet of level alluvium. The first impression given by such a view is uninteresting. We look out over a bare monotonous flat; the roads run for miles, straight as a geometrical line from point to point; the paddocks are square or oblong, and fit together with the dull regularity of a chess board. Most of the country

Fig. 38.—View southward from the Terricks to Mitiamo and the Plain.

is treeless, and only a few dark lines of gums mark the course of the creeks.

To the north the plain extends as far as the eye can see; but on the south we may be able to discern, in the distance, the dim outlines of the old Bendigo pene-plain and its outliers, and the granite peaks of Mount Korong. The eye at first turns to these distant hills

with relief. But as we come to know the plains better we feel more interest in them. We cannot help feeling respect for them, as they are such perfect specimens of their class. Nature decided to have plains in this district, and she has spread them out with magnificent thoroughness. The scenery may not be of the

Fig. 39.—View from the Terricks looking south-westward across the Plains.

highest class ; but of its class these north-western plains are almost perfect representatives. As we come to travel across the plains, we find there is more variety than was at first apparent. My first acquaintance with them was in a ride from Rochester to Mitiamo, via Pannoobamawn. Leaving Rochester I

remarked on the unbroken character of the plains, which appeared as flat as a board. "These aren't plains," said the driver contemptuously; "this is timbered country." And I found that the term plain is confined to the treeless areas, though the timbered country may be as level as the rest.

These plains, though described as geographically level, are not mathematically level. They have a gradual slope downwards to the north, till they reach the edge of some raised land beside the Murray.

Away to the north-west is the **mallee country,** most of which is slightly undulating; close to the surface are layers of limestone, of which the thickest, hardest patches stand out as slight elevations. And as the limestone confines the tree roots to the thin dry surface soil, only such trees as the many-rooted tufts of mallee can resist the strong winds that sweep across this open country.

The treelessness of the open plains may be due to the occurrence of a hard rock layer below the surface; so we must briefly consider the mode of formation of these mallee limestones.

Under most of the mallee country* there are layers of limestone, which have been generally regarded as of marine origin. Travelling across the mallee we find that limestone occurs nearly everywhere, a little below the surface. It follows the contours of the country, rising with the elevations and sinking below the valleys. No sheet of rock deposited on the sea floor could adapt itself to the existing irregularities of the surface, as this limestone does. In some places the

[*An excellent description of it is given by Stuart Murray, Report on Water Supply to the Mallee. Parl. Pap., Vict., J. 1892, p.p. 3-4.]

surface limestone is replaced by beds of chert, a hard compact rock, formed of silica, whereas limestone is made of carbonate of lime.

As these cherts have the same arrangements as the limestones, an explanation of the apparently anomalous distribution of the mallee limestone presented

Fig. 40.—Mallee Scrub near Ultima.

itself. The mallee country is dry, and is exposed to a blazing sun and a parching wind. Any moisture on its surface is rapidly sucked up by evaporation, which sometimes amounts to as much as an inch a day. This loss results in the upward suction of any moisture there may be in the ground below. Thus there is a steady evaporation taking place from the

perspiring surface of the ground. The ascending water is not pure ; it contains some material in solution. The granitic rocks, that are exposed where the bed rock outcrops on the surface, contain some lime ; this may be dissolved as bicarbonate of lime, and deposited when the water evaporates as limestone. The water, passing in places through beds containing alkalies, would become alkaline ; and alkaline solutions will readily dissolve sand grains or any form of silica. When this solution evaporates at the surface, the silica will be deposited as chert or quartzite. In other places the evaporation of water containing iron salts in solution forms a ferruginous quartzite or layer of ironstone, which, as the " cement " of the gold-miners, is well-known in our superficial gold deposits.

These surface limestones, cherts, and ironstones are therefore deposited by evaporation of the water, in which their materials were dissolved.* The distribution of the rocks is directly determined by the surface of the ground. As these rocks are due to the upraising of materials from below, by underground waters, they must vary in position with the irregularities of the surface, from which the evaporation takes place. The character of the rocks will depend on the nature of the underlying rocks, and of the solvent powers of the subterranean waters.

The geographical characters of the north-western plains and the nature of the vegetation that grows on them, are therefore dependent on the distribution of the underground waters, and on the nature of the

* Mr. W. Howchin, of Adelaide University, has advanced the same explanation for the limestones around Adelaide. The hard quartzite crust on the Desert Sandstone of Central Australia has been formed in the same way : it has previously been attributed to volcanic action.

materials, that those waters dissolve, during their ascent to the hot surface of the perspiring earth.

III.—THE SOUTH-WESTERN PLAINS.

The last of the plains are the broad **basalt plains** of south-western Victoria. West of Melbourne, from Mount Macedon on the north, to the Ballarat plateau on the west, and to Geelong on the south, the country is occupied by one vast expanse of basalt. The continuity of the basalt is broken only by sheets of alluvium along the river valleys, and in the old swamps of Bacchus Marsh and Lara; and by occasional hills of silurian rock, such as at Aitkin's Gap, west of Sunbury; and by the granite hills near Bulla and the You Yangs. The western continuation of these plains includes many broad sheets of basalt, and many lava flows from existing volcanic hills. But these plains also include many great lake basins, and broad sheets of alluvium, formed in old lakes and swamps. These south-western plains extend from the Otway Ranges to the Ballarat plateau, forming part of the floor of the great valley of Victoria. The south-western plains from Melbourne, westward, cover about 10,000 square miles.

They are not regular in their surface, and range from the sea level, along the north-western shore of Port Phillip, to the height of 600 feet. The surface of the plains varies considerably; the soil may be thin, but it is always rich. In places there are level sheets of basalt, or the platforms and terraces of successive lava flows; elsewhere there are ridges of piled basalt boulders, forming the well-known "Stony Rises." The

basalt of these plains was ejected from many volcanic vents. Near the vents the material is thicker than it is further away; and so the surface is irregular and humpy.

The lavas of the plains, estimated in years, are old, and as they rise inland to a considerable elevation, rivers have cut deep gorges through them, Thus, even where the surface looks level in a general view across it, the plain is found to be intersected by deep gorges. The banks give instructive sections of the basalts, and show that they vary enormously in thickness. They are thin where the basalt flowed across old plains and ridges; they are thick where the basalt passed into old river valleys, and filled them up level with the plains.

Where the basalt reached the water in these river gorges, or where it flowed over pools or swamps on the plains, the more rapid cooling of the molten lava led to its solidation in the form of columns. The line of a former river channel can sometimes be determined by tracing various points, where the basalt occurs in columns, like masses of great organ pipes.

The fact that the gorges, though deep, are narrow, shows that the basalt plains are, geologically speaking, comparatively young; in time they will be cut wider, leaving basalt capped spurs between broad river valleys, or even isolated basalt buttes, like Mt. Table Top in the Victorian Alps, or Mount Lookout near the track from Wood's Point to Walhalla.

Chapter V.—EVOLUTION OF THE VICTORIAN RIVER SYSTEM.

A.—General Character of Rivers.

The rivers of a country are born, not made. A river system is the product of a slow growth; it is not stamped upon a country by a single geographical incident. The course of a river is the result of a struggle between its waters and the ground of its basin. The water that falls as rain seeks the shortest, steepest route to the sea; and the rocks of which a country is made obstruct the water, and prevent it having a straight, direct course. A river begins as a trickle of rain-water, flowing in gutters down the hill sides; this rill is joined by water that oozes from sodden swamps, or is discharged from springs upon the hill flanks. Many rills of water join to form a stream; streams unite again and again, until the drainage of a wide area is collected into a large and vigorous river. The river rushes with boisterous energy across the part of its basin where the slope is steep; it jumps over rock ridges as waterfalls; it dashes down steep banks in cataracts; it wears away its bed and banks, and carries the material down stream. At length the river slackens its pace, as it meanders across the level lowlands near the sea.

Most rivers show us a passage from a condition of noisy youth among the mountains, to that of sedate maturity on the coast plains. An ungallant geologist once remarked that rivers, like women, are most beautiful when young; for old rivers have so levelled the country they drain, that all the picturesque gorges

and cataracts have been destroyed. A river has a history like a country or an individnal: and the geographer, who knows the facts of a river only at one stage of its existence, is in the position of a biographer writing the history of a man's life from a knowledge of but one incident, or of an historian compiling a history from knowledge of but a single year.

We do not know a river when we know only its present topography: we must also know the successive stages of its growth.

B.—The Work of Rivers.

Before we can trace the evolution of the river system of Victoria, we must get a general idea of the principles of river action.

The first work of a river is **denudation**, which consists in the wearing and washing away of its bed and banks. The river wears away banks of clay and gravel by flowing sharply against them, just as the water thrown from a miner's nozzle cuts away beds of gold-bearing gravel; cliffs of hard rock are undermined by the stream washing against them sand, which cuts into the rock like a file. The river wears away its bed by cutting through rock bars by the scour of sand, or by ploughing up the soft bed by floating logs and trees.

It is necessary clearly to distinguish between the wearing or denuding action of a river on its beds and on its banks. So it is convenient to give them different names. The cutting away and deepening of the bed is known as **corrosion**; the wearing away of its banks is known as **erosion**.

Corrosion is due to the file-like action of the sand and silt carried down by the river, or by the ploughing of the bed by drifting logs and trees. The amount of material a river can carry depends on its rate of flow. If the water of a river contain as much material as it can carry, and its rate of flow be reduced, then part of the load of sediment will be dropped upon the river bed. Any acceleration of the

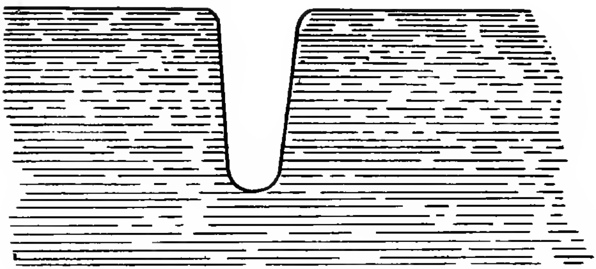


Fig. 41.—Valley formed by Corrosion.

Fig. 42.—Valley formed by Erosion.

flow of a river, on the other hand, leads to an increased scour of its bed and banks; and thus the river picks up a greater load of material. A rapidly flowing river, therefore, deepens its bed until it has reduced it to a slope, at which it can just carry along the load of silt that has been thrown into it, but can carry no more. When the river bed is cut down to that limit, the river ceases to corrode, and is said to have reached its **base level of corrosion.** Corrosion

leads to the formation of a deep, steep walled gully or canyon, like the Werribbee Gorge, or the valley of the Yarra, between Collingwood and Kew.

After a river has reached its base level, it can only erode; and erosion widens the valley by cutting back the banks, till we have a broad flat-floored valley with relatively low and gentle slopes.

The width of the valley that can be cut by erosion is increased as a result of **deposition.** After the river has reached its base level, at each temporary

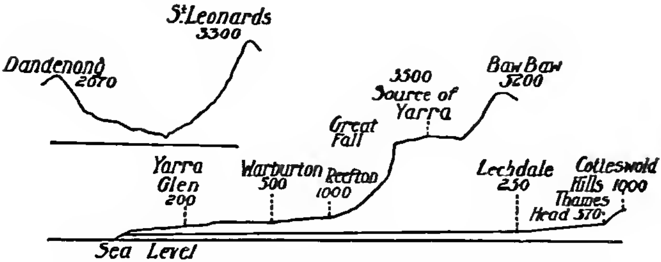


Fig. 43.—The fall of the Yarra River compared with that of the Thames, and transverse section across the Yarra Valley.

slackening of the river pace during dry weather, a layer of silt is deposited over the river bed, which is thus gradually raised above the level of the adjacent flats. At a subsequent flood the river bursts through its wall-like banks and takes a new course. It gradually raises its new bed, till the river again bursts through its banks, and flows over a new bed, of which it raises the level. Thus in time a river wanders from side to side of its valley, till the whole of the floor is raised to one uniform level — the **flood plain.** During these proceedings the river is forced, at intervals, against both its banks, and cuts

them further back. River gullies are therefore widened from narrow gullies separated by broad ridges, into broad, flat-floored valleys, separated by narrow ridges. In time these ridges are broken into isolated hills or "buttes"; and in time even they are are worn away, and the rivers meander through a wide spread level plain.

Hence while the effect of corrosion is to cut the bed of a river down to the curve of the base level, the effect of erosion is to reduce the surrounding country to almost the same level. Thus the effect of the long continued action of a river on a country is to reduce it to an almost plain surface, for which Prof. W. M. Davis has proposed the name of a pene-plain—almost a plain.

This levelling action of a river is due not only to erosion in the upper part of its valley, but also to the deposition of the sediment thus obtained in the lower part of the valley. Rivers are not like steamships, which can carry more material the slower they go. The slower a river flows, the less it can carry. Hence as a river reaches flat country and its rate of flow is slackened, its sediment is dropped upon the bed or spread over adjacent flats in floods, as a flood-plain; or it is piled in shoals in a tidal estuary; or as a delta, where the river is suddenly stopped by entering a quiet sea or lake.

The threefold work of a river is therefore (1) denudation, which is most active in the upper part of the valley; (2) transport, the removal of material obtained by denudation from the upper to the lower part of a river basin; and (3) deposition, which is most important in the lower part of a river valley.

C.—River Systems.

We must also consider how the arrangement of a river and its tributaries is related to the country it drains.

In addition to the active work of rivers, we have to consider the changes in their course due to the

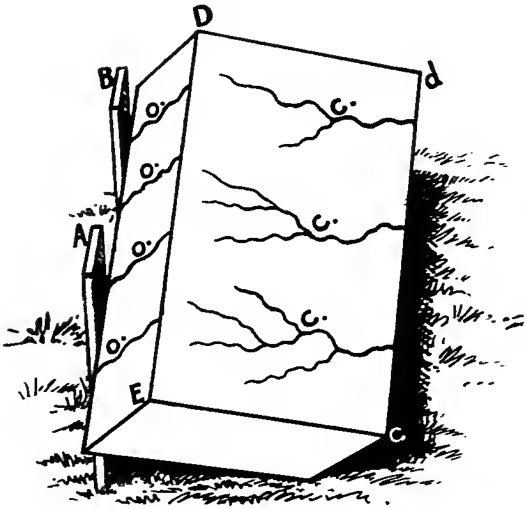


Fig. 44.—Model to show formation of Consequent Rivers (*c*) and Obsequent Rivers (*o*) on either side of the watershed *E D*.

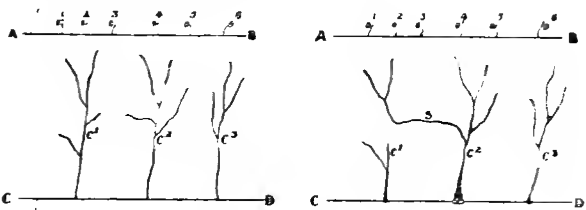
structure and slope of the country which they drain. It will be most easy to understand this question by reference to a simple ideal case. Let us take an oblong board, raised along one of the long sides, to represent a large tract of country; its raised edge would act as a watershed, separating a short, steep face from a long, gradual slope in the other

direction. More rain would fall on the long slope than on the steep face. Most of the rain would run down the long slope, forming a series of approximately parallel rivers. As the course of these rivers would be the direct consequence of the slope of ground, they belong to the class known as **consequent rivers.** The rain that falls on the steep face would carve out steep gullies along it: and these rivers, because they flow in the opposite direction to the main slope, would belong to the class of **obsequent rivers.**

As the consequent rivers deepen their beds by corrosion, they leave ridges between them, and the rain that falls on these ridges will flow into the rivers as tributaries, at say right angles. If all rocks were of the same hardness, and the rainfall of a country were uniform, valleys would maintain their primitive arrangement. But even along the same line of hills the rainfall is not uniform, and rocks are of varying strength. The river, which receives the most rain, or flows along a band of soft rock, will corrode its bed more quickly than its neighbours: and thus it and its tributaries will flow at a lower level than the adjacent rivers. If one of the tributaries of this active river strike a line of weakness, it will rapidly enlarge its valley; it will cut back the ground at its head, and may tap the water courses of the next river system. Thus the tributaries of one river may in time capture the waters of its more sluggish neighbours. "To him that hath shall be given" is a law of Nature that applies to rivers. A river which has had part of its waters captured by the next river system, is said to be "beheaded." As the course of the capturing tributary and the captured part of the

next river is not dependent on the original slope of the country, but to causes that acted subsequently to the establishment of the main slope, these rivers are said to be **subsequent.**

In the diagram (Fig. 45), A and B represent the ridge or watershed; C_1, C_2, C_3 are three separate consequent streams and their tributaries. In stage *b* by the deepening of C_2, shewn by its wider estuary and more extensive estuarine deposits (the shaded area), its tributary has worked backward to the valley of C_1, and captured the head of that stream. The tributary S is therefore a subsequent river.



a *b*

Fig. 45.—Diagram illustrating the alteration in Rivers by Capture.
(*a*) Original courses of three consequent rivers (C1, C2, C3) from the watershed A B to coast line C D.
(*b*) Capture of head of C1 by S a branch of C2. O 1-6, six obsequent streams.

Another change in the relations of a river to the slope it drains is due to earth movements. An uplift may raise a ridge across the course of a river. If the uplift be rapid, the ridge will act as a dam and a lake be formed above it. The level of the water in the lake may rise till it finds an outlet across a gap in the side of the valley; so the stream may be permanently diverted from its original course. But if the uplift be slow, then the corrosion may be able to keep pace with the uplift; the riverbed is kept at its

original level, while the banks on either side are raised. The river maintains its former course across the rising ridge of rocks, and flows through a deep gorge. In this case the river is older than the hills it crosses, and is therefore said to be **antecedent.**

D.—The Victorian River System.

Now let us apply these considerations to the river system of Victoria. It will be helpful to remember that our existing river system began its development long after the elevation of the Primitive Mountain Chain of Victoria. This Mountain Chain in eastern Victoria lay along the northern edge of the country, which had a short, steep, northern face, and a long, gradual southward slope: in western Victoria the axis lay more along the middle line of the country, so that there was a more equal slope to north and south, as in a roof with a central ridge.

Eastern Victoria is therefore in much the same condition as our ideal board on page 102. It had a steep northern face, and a long southern slope. Therefore, we should expect to find that the rivers first ran southward as a series of consequent rivers, while short obsequent rivers cut shorter valleys and gullies in the northern face.

Instead of that arrangement, we find the three chief rivers, the Yarra, the Upper Goulburn, and the Latrobe, are flowing east and west. Moreover, some of the northern rivers, such as the Mitta Mitta and the Ovens, are long, and rise far south of the Primitive Mountain Chain.

Study of the river system of eastern Victoria shows that the existing arrangement is of recent date, and

that there are traces of an **older river system** which was on the plan, which the original structure of the country would have led us to expect.

Let us go to the Trigonometrical Station on the summit of Mt. Dandenong, and take a general survey of the country. We see that we are on a ridge running north and south, and separating two great basins; to the west is the Melbourne basin, with Port Phillip, the broad plains beyond the Saltwater River, and the valley of the Plenty River and the Lower Yarra.

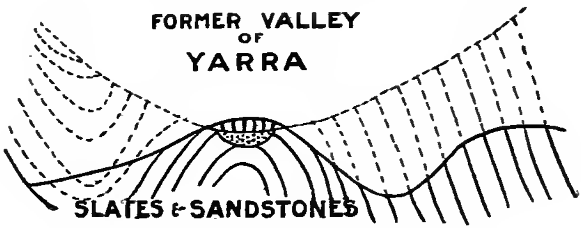


Fig. 46.

Diamond Creek. — Kangaroo Ground; lava-capped hill covering former bed of Yarra, or of one of its tributaries. — Present Valley of R. Yarra.

The dotted lines show the former level of the land, when the Yarra was flowing over the summit of the Kangaroo Ground.

To the east is the basin of the Middle-Yarra, with the broad plains of Yarra Glen, and, away to the south-east, the great, low-lying basin of the Woori Yallock. Secondly we note that the **Yarra** does not cross from its Middle basin to its Lower basin by what appears to be the natural course, viz., through the gap at Mooroolbark used by the railway; but after meander-through the Yarra Flats, the river suddenly turns off into the hilly country, known as the Christmas Hills. It flows in a deep gorge through them, till it reaches

Don Rangss. R. Yarra at Warburton. Basin of Middle Yarra.

Fig. 47.—View looking eastward across the Woori Yallock Basin.

the plains again, near its junction with the Plenty River. Its course through this Christmas Hill country is therefore clearly antecedent to the present topography of the country; but its narrow gorge, and rocky, cataract broken course, show that it has here the characters of a young as well as an antecedent river. The river, in fact, has been revived.

Looking across the Woori Yallock basin to the hills that form its eastern border we see that they form a long range, sloping to the south; the hill crest is here and there notched and irregular; but a line joining the points on the range has a steady southward slope. Going to other view-points in the same district, we see that, at one time, this country must have been part of a pene-plain with a slope to the south; down this slope rivers flowed at right angles to the course now followed by the Yarra. Remains of the valley of these older rivers are well marked; thus the ridge that forms the main watershed of Victoria (the Main Divide) is

notched by a river-cut depression — the **Kinglake Gap** north of Yarra Glen; and the divide between the Yarra and the rivers of Gippsland is notched by a similar depression east of Gembrook —the **Beenak Gap**—connecting the basins of the Woori Yallock and Koo-weerup Swamp.

Moreover, if we cross the Main Divide to the Cathedral Range and look from it over the Acheron Valley, we see that although we are on the north side of the Divide and the river flows northward, yet that the opposite hill range slopes steadily downward to the south; at the head of the **Acheron** is a gap leading over to the Yarra; while the highest land, instead of being on the Divide, is in the Strathbogie Ranges on the northern side of the Goulburn. Though the drainage here is now flowing northward,

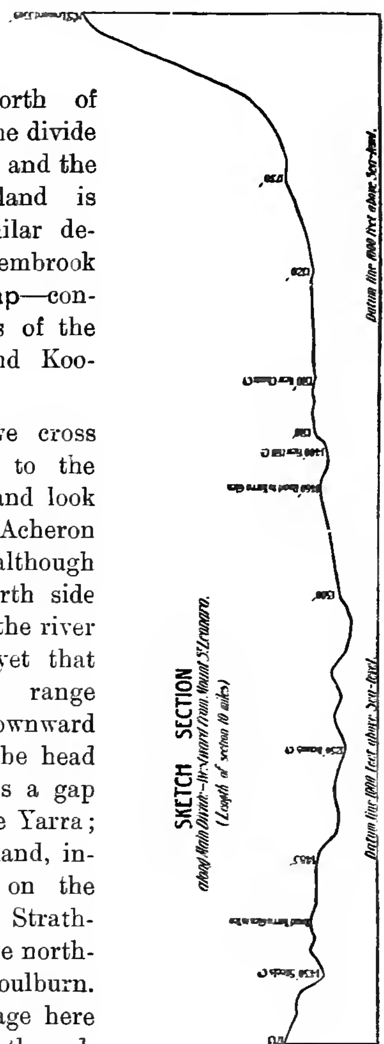


Fig. 48.—The Divide and Kinglake Gap. (From a survey by Mr. S. Easton.)

the evidence of the old pene-plain shows that at one time it must have flowed to the south.

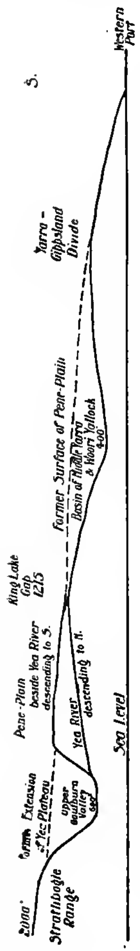


Fig. 49.—The slopes of the former and present rivers between the Strathbogie Range and Western Port.

The evidence shows, therefore, that at one time the **Strathbogie Ranges** were the main divide ; and that from them a river flowed southward along the line of the Acheron, over the Kinglake gap, and across what is now the basin of the Middle Yarra. Further south, the river crossed the divide between the Yarra and Gippsland through the Beenak Gap.

This low gap on the divide was no doubt made by the stream, which discharged the waters of the Acheron and the Middle Yarra through Kooweerup Swamp, and thus carried their waters to the sea through its estuary of Western Port. Thus the Acheron, Middle Yarra, and one of the creeks flowing into Kooweerup were originally all part of one consequent river. It has been broken up into three different rivers by the Goulburn and the Yarra, which are two subsequent rivers, having cut their way east and west across the country. The Acheron was slowly diverted to the Murray basin, as the Goulburn cut its way through the Strathbogie Ranges at Trawool, and then, guided by the line

[One low point on this divide occurs between the head of the Bunyip and one of the tributaries of the Yarra.]

of junction of the granites to the north, and the slates to the south, excavated the basin of the Upper Goulburn. The Woori Yallock was captured by the Yarra, which cut its way along an eastern and western valley, guided by the earth movements that succeeded the eruptions of Dandenong and the Blacks Spur.*

The drainage into **Port Phillip** and **Western Port** was probably once as follows. The two estuaries received the drainage of three main rivers flowing from the granitic rocks of the Primitive Mountain Chain. The westernmost of the three rivers was the **Saltwater,** which rose on the granites of the Cobaw Ranges. It drains the eastern part of the basalt plains, and, before the eruption of the lavas of Mount Macedon, probably received from the north of that mountain some of the drainage which now flows into the Campaspe. The Primitive divide, north of Macedon, is at the altitude of over 2000 feet; the slates under Macedon are at the level of 1500 feet; west of Macedon, on the Woodend road, the slates rise to the level of 1923 feet; they also occur at over 1900 feet to the east of Macedon. So that if we reconstruct the surface that existed before the volcanic eruptions, we find that there was a valley with a southward slope from a divide in the Cobaw Ranges. The upper part of the Campaspe is an obsequent stream, which has cut its way southward and captured the headwaters of Riddell's Creek, and of the western branches of the Saltwater; it has also

*The only previous suggestion as to the age of the Yarra, which I have seen, assigns the river to a much earlier age. It is given in Mr. T. S. Hall's interesting account of the Geology of Melbourne, published in the handbook for the meeting of the Australasian Association for the Advancement of Science, 1900.

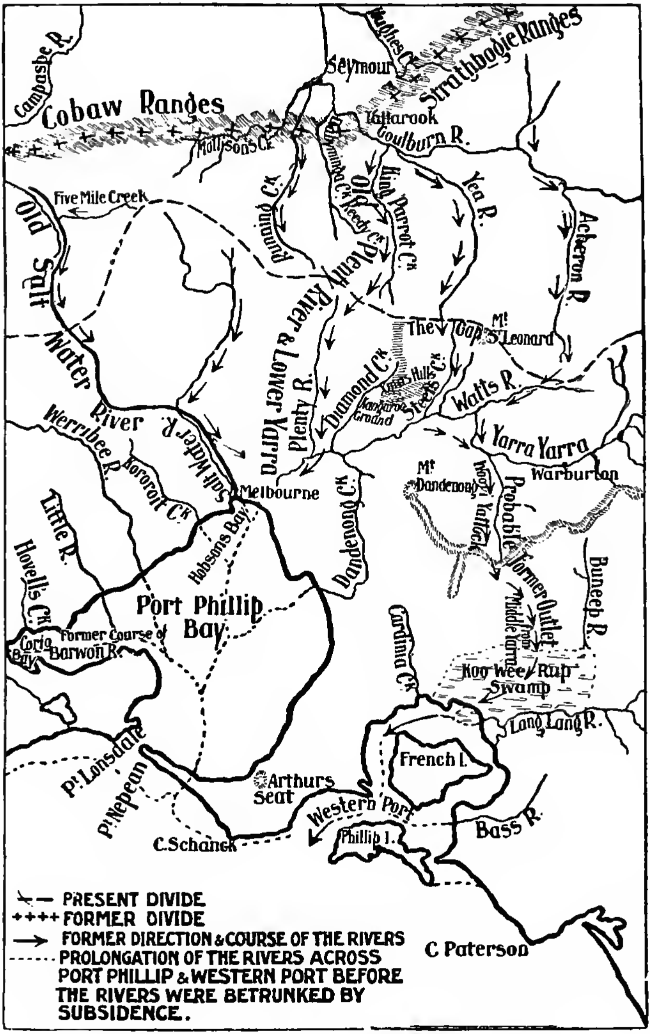


Fig. 50.—Present and former Drainage into Port Phillip and Western Port.

captured the Five Mile Creek, which is a subsequent river, between the Cobaw Ranges and Macedon.

The next river to the east is the **Plenty River,** which now rises in the Hume or Plenty Ranges, near Mount Disappointment, and flows south through a broad, mature valley, till it joins the Yarra at Eltham.

Near Melbourne the character of the valley changes; for it flows through a deep gorge, which has all the characters of a young valley. This change is due to the fact that the old valley has been filled up by the flood of lava which forms the Collingwood Flats, between

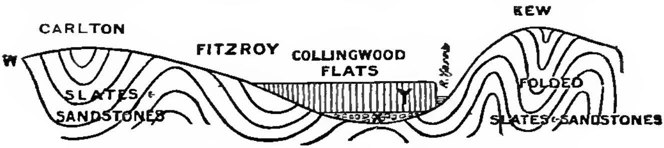


Fig 51 —Section across the Yarra from Carlton to Kew.

the ridges of silurian rocks, at Carlton and Kew. The Plenty and Lower Yarra have had to cut their channels anew, and, owing to the hardness of the basalt, the river has corroded its bed along the junction between the basalt and the softer sandstones and shales. (See figs. 51 and 52.)

The **Plenty** rises on the southern side of a gap through the present Divide near Mt. Disappointment: on the northern side of the gap is the valley of King Parrot Creek; and, though this valley bottom has a slope down to the north, the ridges on each side continue to rise to the north; so that, if we refill the valley of King Parrot Creek to the level of the gap at its head, we shall have a long river valley rising in the Strathbogie Ranges, and continuing the valley of

the Plenty. The King Parrot Creek and the Plenty River were, therefore, probably originally one consequent river, which has had its upper part diverted by the Upper Goulburn (a subsequent river), into what was once the head of the obsequent part of the original Goulburn.

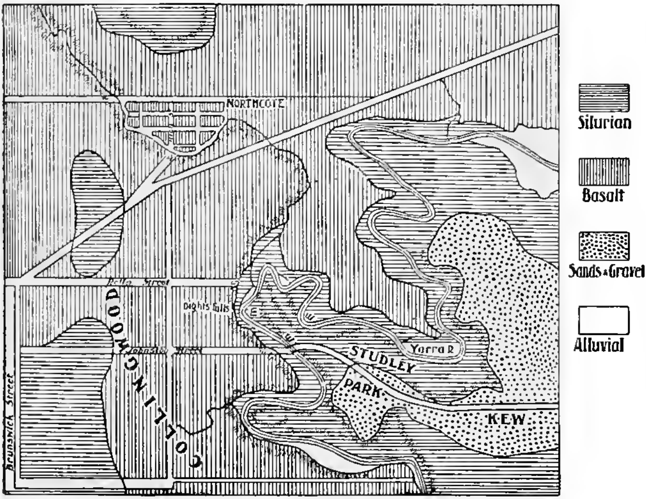


Fig. 52.—Meander of the Yarra at Kew.

The third river of this series also formerly rose in the Strathbogie Ranges; its upper part is now the **Yea** River, now diverted, like the King Parrot Creek, into the Goulburn. The formation of the Valley of the Yea was begun by a river which crossed the Kinglake Gap, and flowed southward along Steel's Creek to the Yarra Flats. Then, probably at a time when the surface of the country was some 600 ft. higher than at present, it continued southward across the basin of

the Middle Yarra. Here it was joined by a tributary from the North East, formed by the Acheron and the Watts. The joint streams passed across the Woori Yallock basin and over the Beenak Gap, and so through Kooweerup to Western Port. Western Port was then the estuary of the great river, which discharged the drainage of the Middle Yarra and the Acheron.

A fourth river with a similar history occupied the uppermost part of the Goulburn valley, between Mansfield and Wood's Point. That the surface slope here was once from north to south, and that the valley-floor rested in places on the tops of the existing ridges, is shown by some old patches of lava. A ridge runs southward from the Main Divide by Mt. Singleton through Mt. Lookout, and dips below the confluence of the Thomson and the Aberfeldy. This ridge is capped at intervals by patches of basalt. This basalt is probably the remnants of a long lava flow, which once ran down the floor of a valley. Denudation removed the soft sandstones and shales that formed the banks of this valley, more readily than it could attack the hard basalt on the floor of the valley. So the line of the old valley is now the summit of a high narrow ridge.

Further evidence in this case is afforded by the fossil bed of this **Upper Goulburn-Thomson River,** which is preserved below these basalts. This river drained into the Gippsland estuary.

East of the Goulburn-Thomson is a group of rivers which have been beheaded in a different way.

In the North East of Victoria the Main Dividing Range carefully avoids the highest peaks, which, like Buffalo, Feathertop, and Bogong, lay far to the north

of it. The high plains of Dargo and Bogong, and Mt. Tabletop are basalt-capped plateaus; they were originally valleys down which flowed streams of basalt; denudation has removed the banks and cut deep gorges far below the level of the floors of the old valleys. All that is left of the valleys is lines of old river gravels,

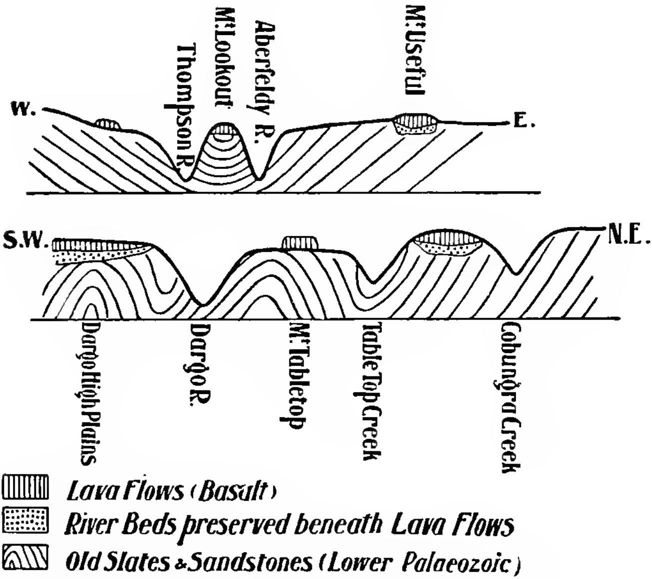


Fig. 53.—Sections across Thomson and Aberfeldy Rivers, and across Dargo High Plains and Mt. Tabletop.

now buried beneath the basalt. The levels show that the valleys were those of rivers, that rose far to the north of the present Divide. But these rivers have been cut short; and their head waters, instead of flowing south into the Southern Ocean, now flow into the Murray. These head streams have been captured by the Mitta, the Kiewa, and the Ovens, which

are obsequent streams, that have cut their way southward through the old Divide. The deep gorge at the head of the Kiewa, between Mts. Feathertop and Fainter, north of Cobungra, is evidence of changes in the river system in the Dargo-Bogong area.

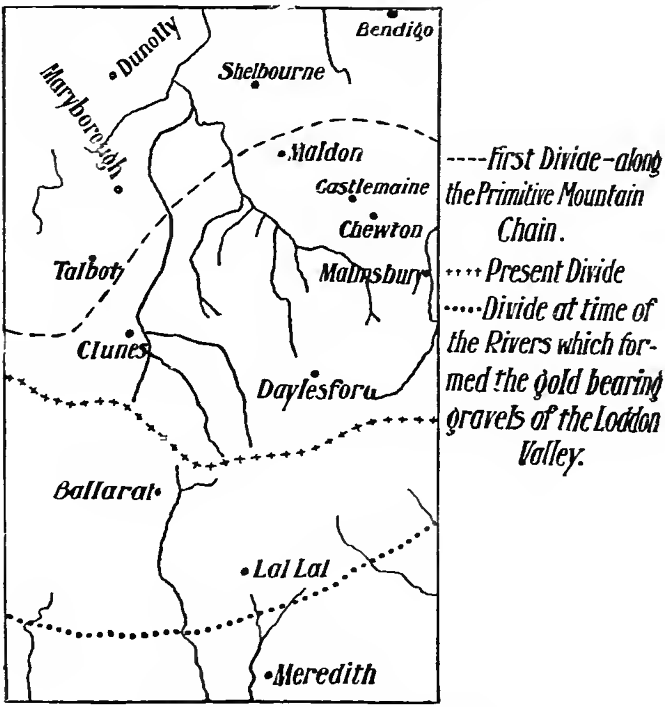


Fig 54.—Changes in the Divide near Ballarat.

In Western Victoria, the old Divide and the present Divide are much nearer together than in the eastern part of the state, and the history of the rivers is in general less complex. The Loddon, however, has

suffered a double change in the position of its watershed. The oldest recognisable divide in this district is the Primitive Mountain Chain, which crossed the Loddon valley belween Mts. Tarrengower, near Maldon, and Rodborough ; this line was cut through by the Loddon, which captured the waters of the southern rivers as far south as the hills of Smythesdale, south of Ballarat. The present Divide, moreover, is north of Ballarat, and is formed by a basalt-covered plain. An area of 300 square miles, which originally belonged to the Loddon, now discharges to the Southern Ocean by the Yarrowee. This change of position in the Divide was caused by the basaltic eruptions, which formed a dam across the Loddon valley north of Ballarat; the water accumulated on the southern side of this dam as a lake; its level rose till it reached a gap across the hills to the south, and flowing out through it, the rivers were able to work out a new passage for themselves to the south. Still further west, the old and new Divides are in places practically coincident, as, for example, near Ararat.

In Southern Victoria the rivers show interesting changes in their courses. In the Upper Barwon the late V. R. Stirling recognised a clear case of river capture. Standing on the ridge above Mackie's sawmill, and looking westward, one sees the deep narrow valley of the Barwon. From the ridge (altitude 1450 ft.) there appears to be a straight valley, 3½ miles in length : the stream in this valley appears to flow due westward, and to join the eastern branch of the Barwon at about a mile and a half from the ridge. No doubt it did so formerly. But this apparently continuous valley is now broken by a low barrier (1000 ft.

above the sea level), which cannot be seen from the ridge: and the tributary, that rises west of Mackie's

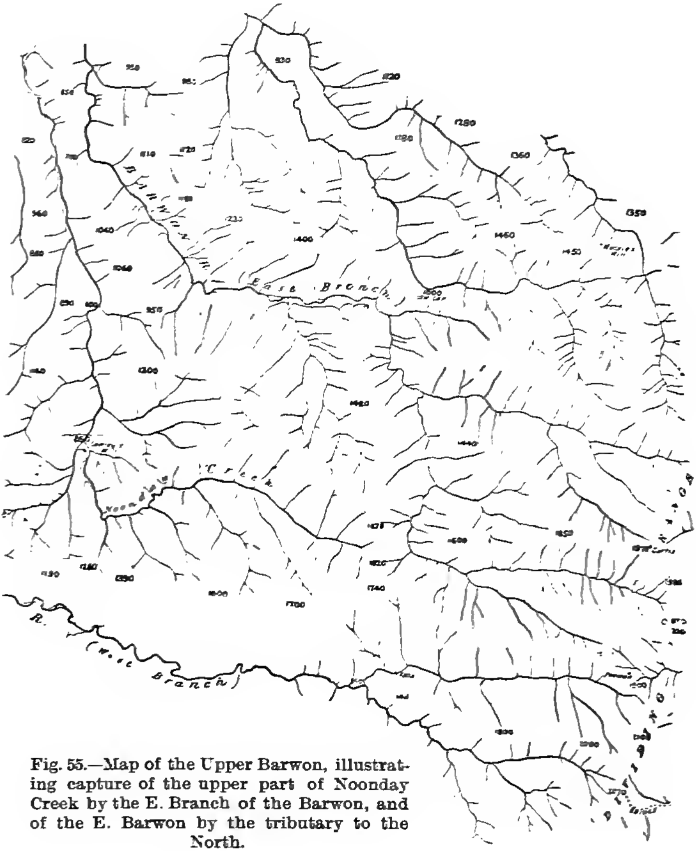


Fig. 55.—Map of the Upper Barwon, illustrating capture of the upper part of Noonday Creek by the E. Branch of the Barwon, and of the E. Barwon by the tributary to the North.

Mill, flows through a breach in the northern bank of the valley, and joins the East Barwon only some miles further down its course.

The lower Barwon shows a different type of change; it must once have flowed into Corio Bay, which was its estuary; but the lava flow, which forms the long ridge running northward from Geelong, dammed up the old valley; and the river being unable to cut

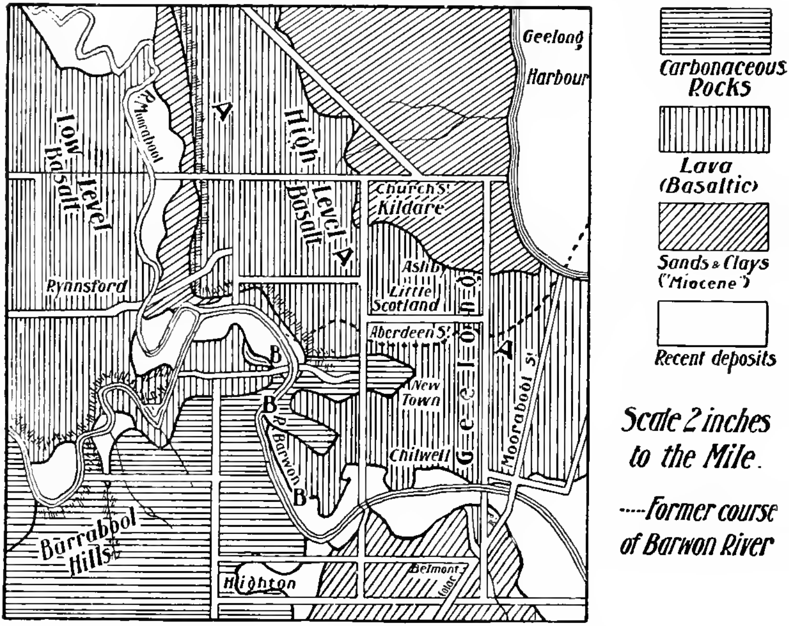


Fig. 56.—Map of Division of Lower Barwon, near Geelong.

through the hard basalt, has worked its way southward, and joins the Southern Ocean independently of Port Phillip.

We have thus seen that many of the Victorian rivers, which were once separated, have now been joined by their increase in length, and by the

tributaries of one river beheading the upper waters of another. There are also cases in which rivers that were once united, have now become separated. This

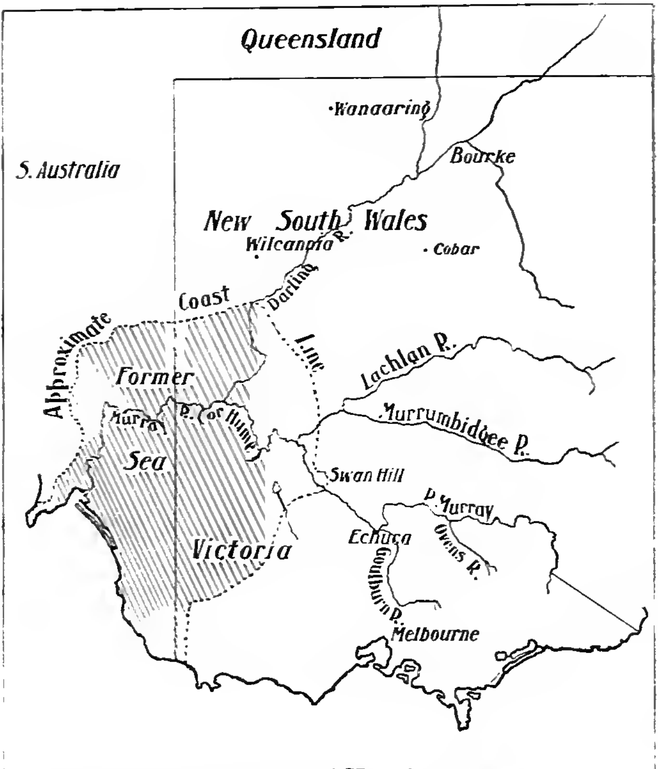


Fig. 57.—Map showing engrafting of the three branches of the Murray.

change generally results from the loss of the lower part of the main trunk stream, by its being flooded from the sea. Professor W. M. Davis has suggested the term **betrunked** for the case of rivers

thus treated. A Victorian illustration of betrunking is given by the rivers of **Port Phillip** (see fig. 50, p. 111). The Werribee, the Little River, the Yarra, etc., are now all separated from one another, and enter Port Phillip independently. But at one time these rivers were probably all tributaries of one river, which flowed across the plains that now form the floor of Port Phillip, and entered the sea by one mouth south of the present shore line. Thus what was originally one river has now been broken up by the formation of Port Phillip into several distinct rivers.

The converse of betrunking is the process of **engrafting,** in which rivers that were once independent have been grafted on to a common trunk. Most of the big rivers of the world have been formed by the union of many rivers, originally separate, which have been engrafted into a compound river system. The best illustration of this process in Australia is supplied by the **Murray.** The Murray is a compound river, formed by the engrafting of the Darling, the Murrumbidgee, and the upper part of the Murray, which was originally called the Hume. These three rivers at one time entered, independently, into a great estuary, which ran northward up the Murray Valley; but by the retreat of the sea, the three rivers have been engrafted on to a common trunk—the Lower Murray. A simpler case of the same process is supplied by the rivers in Gippsland. Here a series of rivers, the Thomson-Aberfeldy, Macallister, Avon, Mitchell, Nicholson, and Tambo Rivers, which were originally independent, have, as we shall see later on (see fig. 65, p. 138), all been grafted on to one estuary, and enter the sea by one mouth.

The **Wimmera**, in north-western Victoria, supplies another illustration of the engrafting of rivers, as, according to Mr. Stuart Murray,* the Wimmera River has been formed by the union of three rivers originally distinct. He says that—

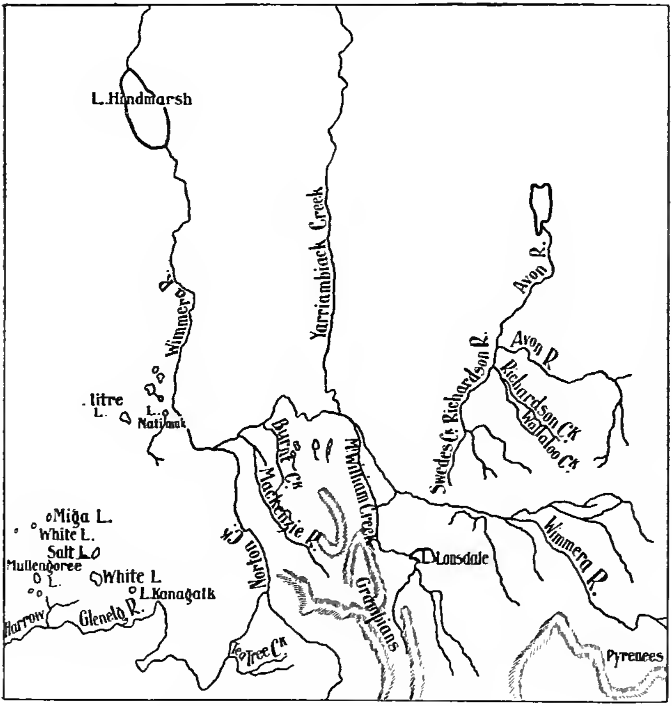


Fig. 58.—The Wimmera River System.

"A very peculiar feature of the physical geography of the Wimmera country is the fact that the Wimmera River, as we now know it, seems to have been at one

* Report on Irrigation in Victoria: Its Position and Prospects., Parl. Pap., Vict., 1892, 4456, p. 21.

time three rivers, with three distinct and separate sources, and with separate debouchments. First, in the east, there is the eastern or upper portion of the existing river, which drains the greater part of the Pyrenees, and probably had its outlet by two mouths—one by way of the Swede's Creek and the Richardson River, and the other by way of the Dunmunkle Creek; then there is the Little Wimmera or Mt. William Creek, having its sources in the western Pyrenees and the eastern Grampians, and its outlet by way of the Yarriambiac; lastly, there are the Burnt Creek, the Mackenzie River, and the Norton Creek draining the western Grampians and the north-east slope of the Sierras, and having a common outlet by way of the existing Lower Wimmera and Lake Hindmarsh."

Chapter VI.—THE LAKES OF VICTORIA.

The lakes of Victoria belong to five classes:—(1) The lakes of the plains of south-western Victoria; (2) the lakes of the Wimmera in north-western Victoria; (3) the Gippsland lakes; (4) the lakes of the river flats of the Murray and its tributaries; (5) the small isolated mountain tarns.

A.—The South-Western Lakes.

The first group includes the greatest of the Victorian lakes. They are scattered over the volcanic plains of south-western Victoria, between the old rocks of the Victorian Highlands to the north, and the Otway

Ranges to the south. The lakes are irregular in shape, and are very irregularly scattered over this area; they are very numerous; and the map of Victoria on the scale of 8 miles to the inch, published by the Surveyor-General, shows 145 lakes in the Great Valley of Victoria, between longitudes 144° and 141°. The largest is Lake **Korangamite,** which extends for 20 miles from north to south, and varies in width from 3 to 6 miles; it is long and broad, and has an irregular outline. Other lakes of this group, which resemble Korangamite in their general character, are Lake **Kolongulac,** which trends from north-east to south-west, and Lough **Calvert,** which is long and irregular, but is very narrow.

A second group includes lakes which are either oblong or elliptical; this group includes Lake **Colac** and Lake **Burrumbeet,** near Ballarat.

A third group includes those which are small, and roughly circular; Lake **Wangoom,** eight miles east-north-east of Warrnambool, is a good representative of this type. Others are Lakes **Gnotuk, Bullenmerri, Elingamite, Keilambete, Purumbete** and **Tower Hill,** Koroit. These small circular lakes have been regarded as crater lakes, *i.e.*, lakes occupying the hollows of extinct volcanic craters. This assertion is made in regard to Purumbete, Gnotuk, and Bullenmerri. Tower Hill, Koroit, also, is often claimed as a crater lake; but Mr. T. S. Hart* holds that it occupies a hollow, formed by a volcanic explosion.

None of the large lakes of the western plains has been carefully surveyed by sounding. Until this has

* T S. Hart, Victorian Naturalist, Vol. XVII, 1901, p. 159

been done, their origin cannot be finally settled. This work would form a useful and interesting holiday

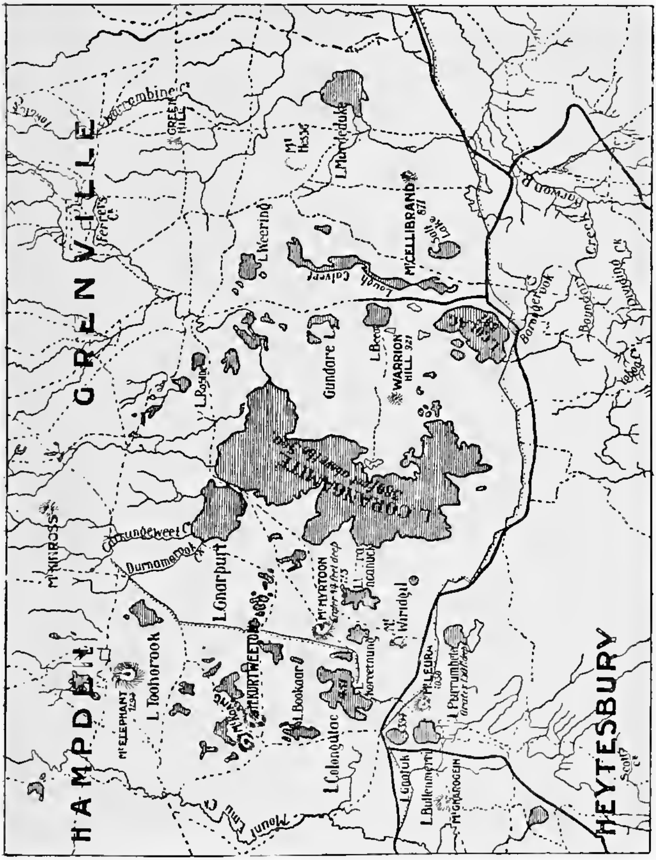


Fig. 59.—The Lakes of South-western Victoria.

exercise. The large lakes are most probably due to subsidences of the ground forming basins, in which water collects as lakes. Such subsidences generally

occur in volcanic countries. The eruption of the lava from below the ground leaves subterranean cavities, or areas insufficiently supported. The ground above such areas subsides, and depressions are then formed in which the water collects as lakes.

An instructive Victorian illustration of this action is afforded by the mining of the deep leads; they are the gold-bearing gravels of former rivers, now covered by layers of other rocks. Where the leads are covered by beds of gravel and clay, the surface sinks within twelve months of the removal of the underlying gold-bearing gravels; water collects in the depression thus formed, and the course of the gold-mining operations is often marked out by a long, narrow lake or line of pools. Such lakes, due to subsidence, are especially well shown on the Chiltern gold-fields.

Lake Korangamite is the largest lake of this series; its area is 72 square miles. Moreover, it apparently always contains water, whereas many of the other lakes are often dry. It occupies a low depression, which receives the drainage of a large tract of country to the south, north, and west. Much of lake Korangamite is shallow, but some parts of it are said to be deep, and, even at the end of such a dry season as the summer of 1902-3, it presents a noble expanse of water. Some of the other lakes on the western plains are very shallow, or contain no water at all, as was the case with Lake Kolongulac, in November 1902. This lake is one of a numerous series of shallow lake basins, which are often dry; when they contain water, they discharge their overflow into Lake Korangamite.

Lake Gnotuk. Lake Bullenmerri.

Fig. 60.—View of Lakes Bullenmerri and Gnotuk from the hills to the W.

The smaller, rounder lakes may be of two distinct origins. I have examined four of the Lakes, which have been described as occurring in the craters of extinct volcanoes. A photograph of Mount Eels (Eccles), taken by Mr. A. E. Kitson, suggests that this lake lies in a true crater; but the so-called crater lakes in the area round Camperdown and Terang must receive a different explanation.

The two best known lakes, which have been regarded as occupying volcanic craters, are **Bullenmerri** and **Gnotuk**, to the south-west of Camperdown. They both occur in steep-walled, flat-floored depressions in a down-shaped hill of bedded volcanic tuff.

This volcanic material rests upon a bed of clay that was formed beneath the sea. The volcanic tuffs were accumulated beneath water, and in most cases the material has been sorted and rounded by water action. The sides of the down-shaped hill, which encloses the lakes, do not represent the slopes of an old volcano. The hill is a remnant of a vast sheet of volcanic tuff that was once spread widely across the surrounding country. The existing slopes are simply due to denudation. The lake basins have been formed by a subsidence that has cut across the mass of tuff; this subsidence has made three great depressions. The one to the south is dry; the second one is occupied by Lake Bullenmerri, and the northern one by Lake Gnotuk. The three basins are separated by narrow transverse ridges. The level of the water in Lake Bullenmerri is about 140 feet higher than that in Lake Gnotuk, but the level of the beds of the two lakes is the same. As the water drains from Lake Bullenmerri into Lake Gnotuk, the former has an outlet, whereas the latter has none. It is therefore only natural that, while the water in Lake Bullenmerri is fresh, that in Lake Gnotuk is salt.

These three saucer-shaped lake basins are not crater lakes, for there is no evidence that either of them occupies the crater of an old volcano. The materials of their banks do not agree either in material or arrangement with the walls of volcanic craters. Indeed, low cliffs of marl and clay, containing marine fossils are exposed at many parts on the lake shores.

[For definition of crater, tuff and other volcanic terms see pp. 183-4.]

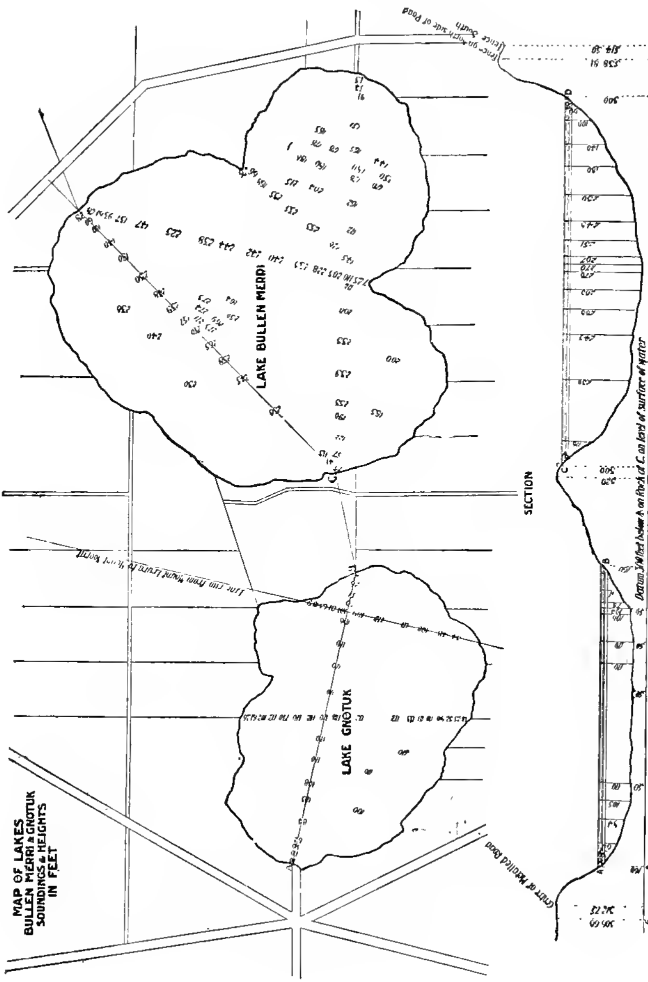


Fig. 61.—Map and Section of Lakes Bullenmerri and Gnotuk.

Lake **Keilambete**, near Terang, has also been described as a crater lake. It is a nearly circular lake in a saucer-shaped depression in bedded volcanic tuffs, similar to those around Bullenmerri. Lake **Terang** also occupies a hollow basin, formed by a subsidence in bedded volcanic tuff.

All these four lakes are close to extinct volcanoes, the eruptions of which probably caused the subsidences that formed the lake basins. The basins, however, are not volcanic craters.*

Tower Hill, Koroit.

[Since this chapter has been in print, I have had an opportunity of visiting the famous extinct volcano, known as Tower Hill. It is composed of tuff and scoria; the whole centre of the volcano has fallen in, forming a great basin, usually occupied by a lake. A secondary group of volcanic cones has built up from the floor of the basin, and one crater in these hills is still well preserved. The basin is a true caldera, formed by the falling in of the area around the original volcanic vent.—18th May, 1903.]

B.—The Lakes of the Wimmera.

The lakes of the Wimmera occur over the great arid plains in the north-western part of the state. In southern Lowan there are small lakes, which can be numbered by the score. They are either fresh or salt. Many of them are small shallow ponds. White Lake, Tea-tree Lake, and Lake Wallace may be quoted as

*It may be suggested, from the occurrence of ejected blocks of old rocks on the shore of Lake Bullenmerri, that the lake covers an old volcanic vent, and that the lake basin should be regarded as a caldera. A caldera is a basin, formed by subsidence in the surface of a volcanic mountain. The evidence in support of this view is, however, inadequate.

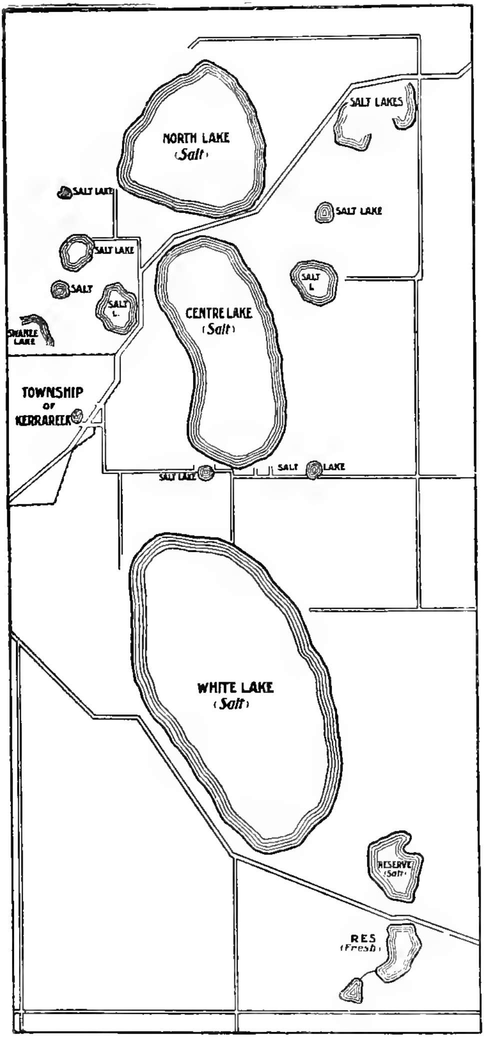


Fig 62.—Map of the White Lake Group, N.E. of Harrow.

Fig. 63.—View of North Lake, N.E. of Harrow.

examples. Some of these lakes occur in the basin of the Glenelg, though they have at present no communication with that river; others, such as Lake **Natimuk**, lie along the course of the Wimmera, though they also are now isolated.

As examples of the small lakes of the southern Wimmera, we may take the **White Lake** group ten miles north-east of Harrow. It consists of White Lake and five smaller lakes, named Centre Lake, Copper-Coloured Lake, North Lake (fig. 62, p. 131). The lakes occur at an altitude of about 550 feet above the sea.

The adjacent country consists of

slightly undulating plains, mostly covered with thin scrub, while some higher land, with better timber, can be seen to the north-west. The lakes themselves are generally elliptical in form; they are all shallow, and occur in saucer-shaped depressions. The shore line is fairly well marked. The banks are mostly steep, and from 10 to 15 feet in height. The banks show many exposures of white, earthy limestone; and I was told that this rock occurs under the soil all around the lakes. Several small streams discharge into the lakes; but the water supply is probably maintained mostly by soakages from the surrounding country.

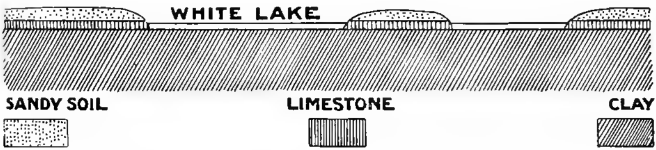


Fig. 64.—Section across the White Lake Group, near Harrow.

The group of lakes has no outlet. Accordingly, as the adjacent soil is saturated with salt, it is only natural that the water in the lakes is salt. In some places in the Wimmera, where the soil is free from salt, the lakes are fresh.

The **White Lake** group is leased out to a salt farmer," who collects the salt toward the end of the summer. The lessee waits until the wind has been blowing steadily in the same direction for two or three days The wind drives the water to the leeside of the lakes, till it is forced up on to the previously dry bed. When the wind drops, a crust of salt is left on the dry bed of the leeshore of the lake, and it is collected before the water covers it again.

These lakes were no doubt formed by subsidences of the ground, due to the removal in solution of some of the underlying material. The white limestone, shown in the lake banks, once extended all across the lakes; it has been dissolved and removed by water, containing carbonic dioxide, or acids derived from the decay of plants. The removal of the limestone formed cavities, and the overlying ground falling in, formed the lake basins.

Many of the so-called "crab holes in the Wimmera District are due to the same process on a small scale. The crab holes, which I have seen, occur where there is limestone beneath the soil; and some residents in the Wimmera District have told me that the true crab holes are confined to limestone districts. The crab holes were formed by the solution of some of the limestone, and the falling in of the ground above. The small Wimmeran lakes may thus be regarded as crab holes of enormous width.*

The members of the second group of the Wimmera lakes are much larger. They occur as expansions of the rivers, that flow northward toward the Murray. The first three lakes of this series are Lakes Lonsdale, Hindmarsh, and Albacutya, all of which occur on the course of the Wimmera River. Lake **Lonsdale** is on the Upper Wimmera: it is a shallow swamp, three feet in depth; it receives the drainage of the Mt. William Creek. Lake **Hindmarsh** consists of a great expansion of the Wimmera, at the height of 211 ft. above the sea; its area is 32,000 acres; it is

*The irregularities of the surface, which occasion "crab-holey country," are probably not all formed in the same way. In some places they may be due to wind erosion, and in others to the expansion of a layer of anhydrite (sulphate of lime) on its conversion into gypsum (hydrous sulphate of lime).

sometimes a fine sheet of water, but once, for 20 years, was so dry that its bed was used for grazing stock. Ten miles further to the north is lake **Albacutya** (210 ft.), which is 12,000 acres in extent; it is generally dry, but is sometimes filled by the overflow from Lake Hindmarsh. The branch of the Wimmera, known as the Yarriambiac Creek, leaves the main river near Longernong, and flows through Warracknabeal, and ends in Lake Coorong. The Richardson River similarly ends in Lake Buloke (438 ft.), north of Donald. The next three lakes of this group are Lakes **Tyrrell** (118 ft.), **Lalbert**, and **Bael Bael**, each of which is on the end of a branch of the Avoca River. Lake Tyrrell is the largest, covering 42,000 acres. Mr. A. S. Kenyon tells me that it is only a swamp, and that several other depressions in the neighbourhood, that are not marked on the maps, are as much entitled to the name of lakes. The last lake of this series that need be mentioned is the small group at **Boort**, at the end of a branch of the Loddon.

These Wimmeran lakes, like those of the first group, occupy a series of depressions. Some of the so-called lakes are mere swamps, or water-logged depressions. Others have bare floors, and, when dry, they are broad sheets of barren clay or loam. Without surveys of the floors of these lakes, only a general suggestion as to their origin is possible. Some of them occupy shallow depressions, which may have been formed by wind erosion. The larger lakes of the series, such as Lakes Hindmarsh and Buloke, are formed by the widening out of the rivers, where they enter shallow depressions in their valleys. Some of this series may be due to the formation of dams

across the river valleys; these dams may have been formed by blown sand, or by the accumulation of flat banks of mud, through which the river has not been able to keep open its channel, owing to the reduction in the volume of its stream.

Some of the other lakes in the northern Wimmera may occupy hollows formed by subsidences, due to solution of underlying rocks. The only lake in the series, which I have seen, is Lake Boort; and, as far as I could judge from a casual inspection from the railway, it appeared to be a basin surrounded by banks of marl and loam. It has probably been formed by subsidence, due to the removal by subterranean waters of beds of underlying limestone, salt, or gypsum.

The Wimmera area was once probably all part of an estuary. As the estuary silted up, sheets of salt waters were left in lagoons; the evaporation of the water led to the deposition of sheets of salt and gypsum, which were subsequently covered by the sands and clays of the present surface. The removal of the soluble material by percolating waters would then inevitably lead to subsidences of the surface. An example of this process is supplied by the Cheshire salt mines; the removal by solution of the beds of rock salt has led to the sinking of the ground above, and the formation of hollows, in which the water collects as lakes.

C.—The Gippsland Lakes.

The Gippsland lakes are, perhaps, the most interesting group in Victoria, and afford instructive object lessons in physical geography. The lakes occupy a series of depressions in the low-lying, level

country at the head of the Gippsland Bight. A geological map of Victoria shows that the older rocks end to the south along a line running east and west across the country from Tanjil to Croajingolong, and passing near the townships of Seaton, Briagolong, Bruthen, and Orbost. Looking northward from the railway between Rosedale and Bairnsdale, the southern end of the old rocks, which are seen to form the bold scarp of the Gippsland Highlands, rise abruptly from the lowlands. These lowlands are either level sheets of recent alluvium, or part of an old coastal plain, uplifted from beneath the sea. This old coast plain forms a heathy, sandy country, rising to about 250 ft. above the sea, and intersected by a series of deep gullies. Its sands and limestones were all formed below the sea. They were laid down on the bed of the old Gippsland Bight, which once reached inland to the foot of the hills of older rocks. A western extension of the coast plain runs along the Latrobe valley; it is separated from the present shore by the eastern part of the ranges of carbonaceous rocks in the county of Buln Buln, in southern Gippsland. These ranges end at Toms Cap (1258 ft.) Between these Buln Buln ranges to the south, and the Victorian Highlands to the north, is the valley of the Latrobe River, which begins to the west of Drouin, and opens out between Traralgon and Rosedale, to the plain of the Gippsland Lakes.

The main **drainage** from the northern highlands is discharged by a series of six rivers, all of which in their upper course run directly from north to south. They are the Thomson-Aberfeldy, the Macallister, the Avon, the Mitchell, the Nicholson, and the Tambo.

The first four of these rivers all suddenly change their course from North and South to West and East, when they leave the Highlands of older rocks. The Thomson-Aberfeldy unites with the Macallister, and together they flow into the Latrobe at Longford, about four miles south of Sale. The Avon enters the north-western corner of Lake **Wellington**, where it adds its current to that of the Latrobe and its tributaries. The united river enters Lake **King**,

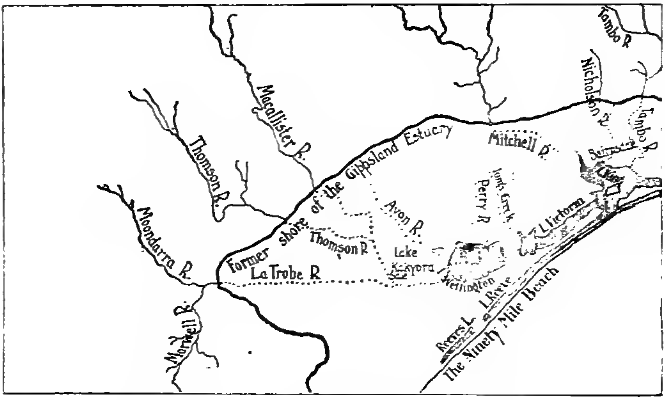


Fig. 65.—Former course of the Gippsland Rivers.

which also receives the waters of the Mitchell, Nicholson, and Tambo. All these six rivers have now one common outlet to the sea at the Lakes Entrance.

When the rocks which form the coastal plain were being laid down, each of these seven rivers had an independent entrance to the sea; but now, by the uplift of the coastal plain and the deposit of sheets of alluvium, they have all been grafted on to one another till they form one system.

The Gippsland Lakes occupy the depressions along the courses of the members of this engrafted river system. The lakes may be divided into four groups. The first, including those along the course of the Latrobe River, includes Lakes **Wellington** and **Victoria**, and the outer part of Lake **King**, between Metung and Cunninghame. The second group lies along the Mitchell River, and consists of the upper part of Lake **King**, with its two great arms, Jones

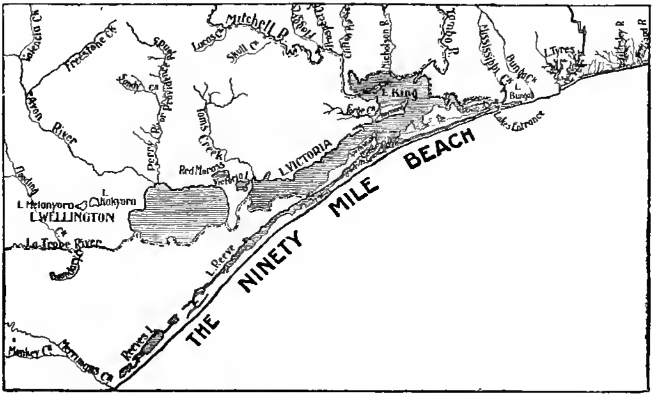


Fig. 66.—Map of the Gippsland Lakes.

Bay and Eagle Point Bay. The third group is formed of a series of lagoons lying behind the Ninety Mile Beach, including Lake **Denison**, Lake **Reeves**, and the long narrow lake known as Reeve's River. The fourth group consists of a series of now isolated lakes, most of which have no permanent outlet, such as Lakes **Melanyora** and **Kakyora**, the **Red Morass**, the **Victoria Lagoon**, and the other lakes and swamps on the northern side of Maclellan's Straits.

All the shores of these lakes are formed of young sandhills, or of the marine limestones and sands of the coastal plain series. The latter rocks once formed a sheet, covering the whole area to a height of probably 200 feet above its present level. The six rivers eroded deep channels through the rocks of this coast plain, and formed estuaries that were once widely open to the sea. They existed as estuaries till no very distant period. I have been told by Mr. A. W. Howitt that some of the natives at Lake Tyers say, that, in their youth, there was no sandbar separating the lake from the sea, and that the surf washed the northern shore of the lake.

The formation of the Gippsland Lakes is a problem connected with the filling up of these old estuaries. The most important factor has been the formation of the **Ninety Mile Beach.** This consists of a line of sandhills, known as the Boole Boole, which lie between the ocean beach on the one side and a long lagoon (Lake Reeve and Reeve's River) on the other side. This line of sandhills owes its origin to the powerful south-west current, which sweeps along the shore, carrying with it great quantities of sand. This sand has gradually been laid down across the mouth of the estuaries, by steadily growing from west to east. The wind aided the ocean current, by piling up the sand above the sea level. Scrub and grass grew upon the sandhills, helping to bind the surface, and to build the ridge still higher by collecting wind-borne dust. The oldest part of this line of sandhills is at the south-west. The first act of interference of this eastward growing barrier was to extend across the outlet of Merriman's Creek, forcing its mouth further and

further to the north-east. At length it dammed it up altogether, and then encroached on the mouth of the Latrobe, which probably originally reached the sea through the western part of Reeve's Lake. The advance of the sand along the Ninety Mile Beach deflected the mouth of the Latrobe eastward, until the river was forced to join the Thomson and the Macallister. The irresistible march of this beach material closed successively all the river mouths in the western part of the Gippsland lake area. The rivers now all discharge their waters to the sea by a common entrance near the Red Bluff. This headland prevented the deflection of the river mouth any further to the east, and the waters of the Gippsland rivers were there able to keep open a way to the sea, in spite of the effort of the shore drift to dam up the outlet. But for the occurrence of the hills at the Red Bluff, the Reeve's River would probably have kept on lengthening eastward, parallel to the coast, till it reached Lake Tyers, and thence onward till it joined the Snowy River. It is only the occurrence of the Red Bluff which has prevented the Nowa Nowa and the Snowy Rivers from being also engrafted on the main river system of Gippsland.

The first stage then in the formation of the Gippsland lakes was the accumulation of an embankment, forming the Ninety Mile Beach, and separating the broad Gippsland estuary from the sea. The estuary was thus enclosed as a lagoon.

The second stage in the formation of the lakes was the partial silting up of the lagoon. The unfilled portions remain as the Gippsland lakes. The material

which has filled up most of the old lagoon, came from two chief sources.

Most of the material was brought by rivers from the highlands of Gippsland. All rivers carry more or less mud, and the brown-watered rivers of Victoria, carry an unusually large amount. The amount of silt that a river can carry depends upon its velocity. If the flow of a muddy river be suddenly checked, part of the load of sediment must be dropped. When a river enters a lake, the current spreads outward, on both sides; and, as the width of the current increases, so its velocity decreases. Therefore a river drops most of its sediment as soon as it enters a lake. A familiar instance of this action is the Rhone, which enters Lake Geneva coloured milk-white with glacial mud; but it at once drops this material on entering the lake, and the river issues from the other end of the lake, as clear as the sparkling waters of a spring. A local illustration of this action is presented by the Melbourne water supply. The muddy, flood waters of the head streams of the Plenty River are allowed to stand for a time in the Yan Yean reservoir, where they are cleared by the deposition of their sediment.

Hence the mud brought down by the rivers that entered the Gippsland estuary would tend to be deposited in deltas near the river mouths. But we must remember also, that a river does not flow with equal velocity at all points of its course; the water flows more quickly in the middle than at the sides, and at the surface than on the bottom. In both cases the retardation of the pace is due to friction against the bed and banks of the river. And the friction is greatest where the river is shallowest. Accordingly a

river generally deposits more of its material in the shallows, close to its banks, than in the deep water in the middle of its channel. When a river enters the quiet waters of a lagoon, it drops its sediment on either side of its main channel, and slowly builds up two embankments, which project into the lake one on each side of the river mouth. Fresh sediment will be continually added at the ends of these two headlands. Layer by layer they increase in length, until they project like two mud jetties far out into the lake. Water plants and reeds grow on the banks, and help to raise them above water-level. The plants, moreover act as a sieve and catch the mud in any water that may flow across the banks during floods. Thus the bay between the lake shore and the jetty receives only clear water, and is saved from silting up.

A well-known illustration of this formation of jetty-like banks at the mouth of a river is supplied by the Mississippi. The present mouth is between the ends of jetties, which project 45 miles into the Gulf of Mexico beyond the delta.

The continuous accumulation of mud deposits at the mouth of a river tends to fill up the head of the estuary. This process is aided by another, which affects the whole shore line of the estuary. If the water be salt and tidal, mangroves will grow on the shallow mud flats; the tangled roots of the mangroves will catch the material carried by the tide, the fallen leaves and branches, and wind-borne dust; and thus the margin of the estuary will be slowly raised above water-level. Hence the shore line will steadily encroach upon the lagoon. If the water be fresh, the same process will be carried on by the growth of a

belt of reeds, rushes, or papyrus along the shore line. Most lakes and lagoons have low marshy borders, that have been formed by the slow encroachment of the land on to the area of the water. These marshy borders are well shewn beside the "broads" of East Anglia, where they are known as rands, an old Saxon term identical with the German *rand*, an edge or border.

Both the above processes go on in an ordinary open estuary. But in an estuary that has been converted into a lagoon, owing to the closing of its mouth by a bar, the rate of filling up is much greater; for none of the sediment can be carried out to sea by the river current, or by the daily scour of the tide, as in the case of the Amazon. Any material that is not dropped where the river enters the estuary, or on the shallows along the shore, is caught by the bar, which thus steadily grows inward, increasing in width and probably also in height.

The two processes by which most of the old Gippsland estuary has been filled up are the gradual advance of the land all round the shore, and the projection of deltas and jetty-shaped banks into the estuary at the river mouths. The map of the Gippsland Lakes shows illustrations and the effects of both processes. The mouth of the estuary is closed by the Boole Boole, a narrow bank of land, which separates the ocean beach from the long line of the Reeve's River and Reeve's Lake. This bank is no doubt due to the drift of sand, which is brought by the current that flows eastward along the shore, and which has dammed up successively the original outlets of the Latrobe, the Macallister, the Avon, the

Mitchell, the Nicholson, and the Tambo. The process of drifting is still going on; and, though the training walls of the harbour works at Cunninghame direct the discharge from the lakes, like a jet, straight out to sea, a bar is still kept up across the entrance.

The formation of **silt jetties** is shown most clearly by the Mitchell River. Its mouth was probably once at the head of Jones Bay, two miles south of Bairnsdale; but the formation of two silt jetties has now

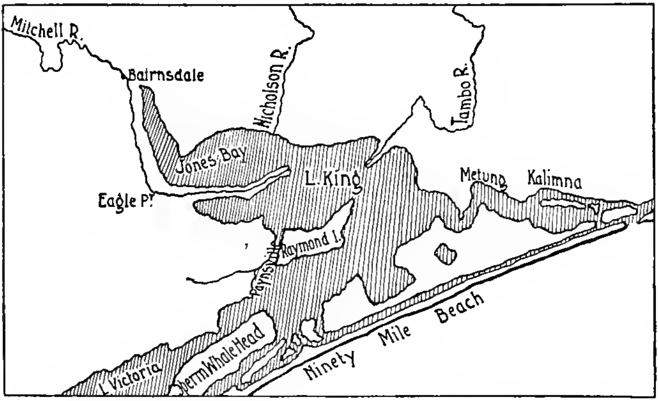


Fig. 67.—Map of part of the Gippsland Lakes, showing the silt jetties at the mouths of the Mitchell and Tambo R.

gone on, till its mouth is now eleven miles further down. The jetty on the right bank is partially separated from the high land on the west by a line of swamp; but this has now been mostly filled in, and it is not until we get to Eagle Point that the two jetties project from the shore straight out into the bay. The river then runs for over three miles, between two tongues of land, which are in places only a few yards across. They separate the river from Jones Bay on

the north and Eagle Point Bay on the south. The process of formation is still going on, and it is stated that the tongues of land have increased a mile in length during the last 20 years. Beyond the present ends of the jetties, are two long narrow shoals, marked out by snags and occasional patches of rushes. In process of time these shoals will be raised level with the surface of the lake, and form further prolongations of the jetties. A similar process is going on in the case of the Tambo River, where the river mouth has now been carried two miles out into the lake. In time the jetties beside the Mitchell will be continued across the narrow neck of water, by which Jones Bay communicates with Lake King, and that bay will be completely cut off as an independent lake.

A strip of land built up in this manner has separated Lake Wellington from Lake Victoria. Tom's Creek from the north has built up a jetty at its mouth. The jetty once formed, was soon increased in thickness by the deposit, on its western side, of material carried into Lake Wellington by the Latrobe and the Avon, and drifted across the lake by the prevalent westerly wind. Accordingly an isthmus nearly four miles in width has now been formed; it separates Lake Wellington from Lake Victoria, except for the narrow passage known as the Maclellan Straits.

The land separating Lake Wellington and Lake Victoria from Reeve's Lake has probably been formed in the main by "rand" formation; and similar rands are now found surrounding most of the lake shores. Sperm Whale Head, which separates Lake Victoria from part of Reeve's Lake, may have begun as a silt jetty and been widened by rand formation.

Fig. 68.—View from the Mitchell River, looking across the right silt-jetty to Eagle Point Bay.

Eagle Point Bay. Mouth of Mitchell R. Jones Bay.

Fig. 69.—Mouth of the Mitchell River between the ends of two silt jetties. The jetties are continued under the lake by shoals on either side of the channel through the lake.

Fig. 70.—View across the Gippsland Lakes from Kalimna.

The lakes which are now completely isolated from the main rivers, such as Lakes Kakyora and Melanyora, were once bays, such as Jones Bay, which have been cut off from the lakes, and then separated by a wide rand.

The Gippsland lakes are to be regarded, therefore, as the remains of a great sheet of water, most of which has been filled up by deltas and rands; and as these processes are still going on, we must expect further changes in the character of the lakes. Their probable future may be seen by reference to the Norfolk Broads, in England. They are a group of lakes of a similar origin to the Gippsland lakes, but in a more advanced stage

of development. There the rivers do not flow through the lakes as the Latrobe flows through Lake Wellington and Lake Victoria, or as the Mitchell flows through Lake King. The Broads have in some cases been completely cut off from the rivers by the lengthening of the silt jetties; the rivers wind through sinuous canal-like channels between the lakes. In other cases the Broad communicates with the river by a few low gaps in the banks. In a third group, the Broads have been cut off from the rivers by wide tracts of land, and they remain as mere ponds in a wide sheet of alluvium.

It is probable that in time Lake Wellington will be cut in half by a jetty formed on either side of the Latrobe; Lake King will loose its communication with Jones Bay; and the jetties at the Tambo mouth will be lengthened till they join the opposite shore of Raymond Island. The various lakes, moreover, will gradually decrease in size by the encroachment of the margin, till they pass into the condition of ponds in the middle of a broad alluvial plain.

D. The Murray Lakes.

The lakes of the Flats of the Murray and its larger tributaries are also due to processes of river deposition. They belong to two groups, (1) lakes in parts of former river channels, and (2) lakes in depressions made by the raising of the river banks.

i. The Lakes of the Old River Channels.

A river flowing in a straight channel of uniform width down a gentle slope, across a country composed of clay, would not long, if left to itself, keep its straight

course. Any one of a dozen trivial accidents, such as the fall of a tree from the banks, the grounding of a floating log, the dropping of a boulder in the stream, would cause an obstruction. Behind the obstacle

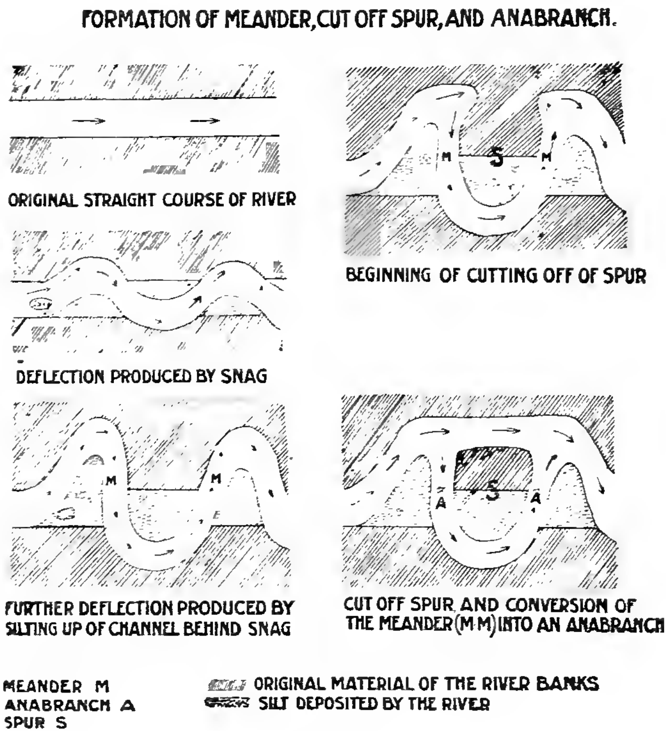


Fig. 71.

there would be an area of still, or "dead water"; therein the sediment brought down by the river would collect as a shoal, which in time would be raised into a small island. The island would deflect the current, and direct it against the adjacent river

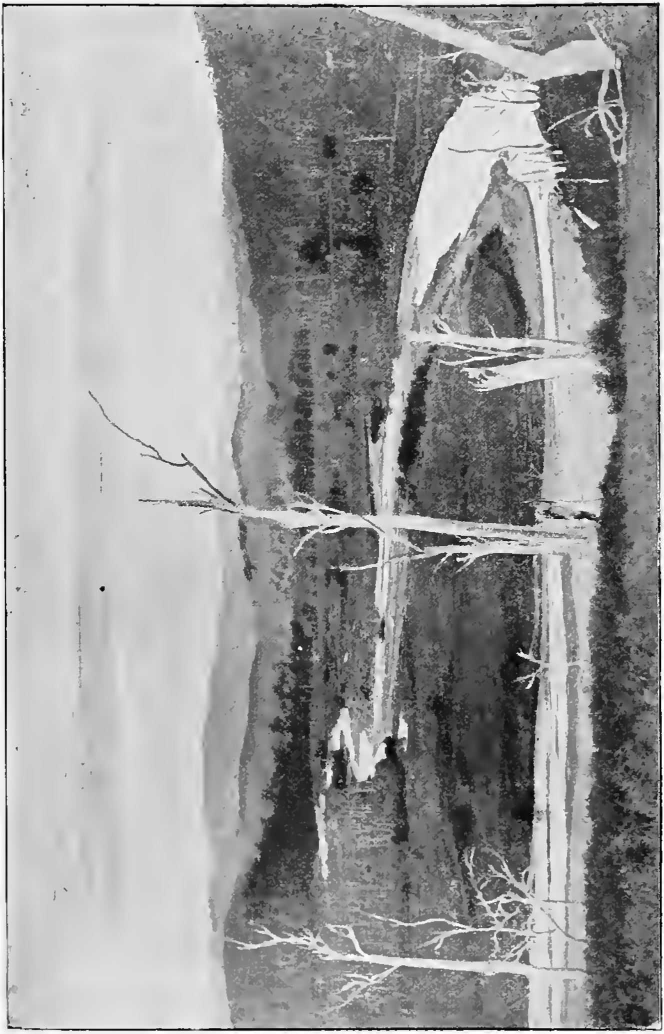


Fig. 72.—Meander of the Snowy River near Buchan.
(*Photo by Mr A E Kitson.*)

bank, which it would gradually cut backward. The current, sweeping round the hollow thus caused, would be again thrown across the stream, and impinge upon the opposite bank. It would wear this bank

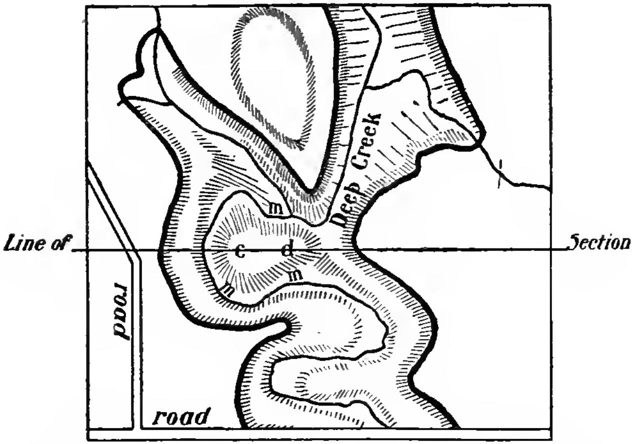


Fig. 73.—Map of part of the Deep Creek, near Bulla. The river now flows in a broad shallow primary valley cut in a basalt plateau; on the floor of this valley is a deep trench occupied by the river, which at *m m* forms a meander around the spur *c d*, which is being cut through at *d*; the entrenched meander will then be left as a cut-off lake or billabong.

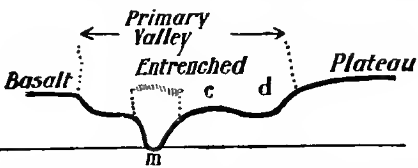


Fig. 74.—Section across Deep Creek, Bulla, along the line shown in fig. 73.

away. Opposite the point of erosion there would be an eddy or patch of dead water, which would gradually be filled up, by a bank, reaching to the water-level. This bank would increase the tendency of the current to flow obliquely across the river from one side to the

other. In time, by the combined processes of the removal of material from points where the current impinges on the bank, and the deposition of the material thus obtained in the opposite areas of dead or shoal water, the river is given a devious, serpentine course. Thus all rivers have sinuous channels. Canals are kept straight only by the care on the part of the engineers in charge of them.

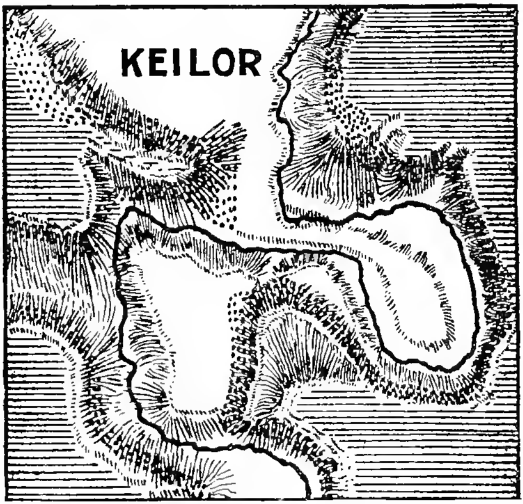


Fig. 75.—A meander of the Saltwater River at Keilor.

Basalt Plateau. River Deposits below the Basalt. Slates and Sandstones (Silurian).

Rivers in low country, composed of soft material, show the extreme development of these sinuous courses. The rivers flow in horseshoe-shaped curves around peninsulas, which may be connected with the main bank by only a narrow neck. Such horseshoe curves in a river are known as "meanders," from the

Meander, a river in Asia Minor, which has an especially serpentine course.

A river not only curves for itself such meanders, but by continuing the very processes that have made them, tends to destroy them. A slight interruption, such as a snag, dropped at an appropriate place in a river, will direct the stream against the neck of land and cut through it, leaving the cut-off spur of land as an island. The river, having once cut through the neck, most of the stream will flow through the short direct passage. Mud will then be deposited by the side of the main stream, across the entrance to the meander, which is now reduced to a backwater. This backwater will then be cut off from the main stream as a lake. Such lakes are known as "cut-off meanders," "ox-bow lakes," or "anabranches,"* or in Australia **billabongs.** Complex series of these billabongs occur along the Murray, where we get them in concentric series, as are shown in the accompanying sketch map of some billabongs near Rutherglen. Isolated crescentic lakes or swamps are numerous on the Murray Flats; as instances, may be quoted the Pelican Lagoon, near Wangaratta, and an unnamed billabong at Tallarook, on the flats beside the Goulburn River.

A good illustration of the formation of these cut-off meanders is supplied by the **Goulburn** River

* The name anabranch is an English term, though it has not been much adopted except in Australia. It is an abbreviation of "anastomosing branches." The term was proposed by Colonel Jackson in 1834. An anabranch is a branch channel formed where a river breaks up into one or more divisions, which reunite lower down the stream. The branch of the Murray which flows on the southern side of Gunbower Island, is a typical anabranch. Some of these branches may be cut off by silting, and leave long sinuous lakes. Long Lake, near Swan Hill, may be quoted as an example of one of these anabranch lakes.

at Seymour, to which my attention has been kindly called by Mr. Hardy, of the Lands Department. The Goulburn, near Seymour, was surveyed by Pickering in 1841, and re-surveyed in 1855 (probably by Pinniger), and again in 1859.

Information as to the course of the river in later years has been kindly given by Mr. Hardy and Mr. J. M. Coane. The various positions of the river during

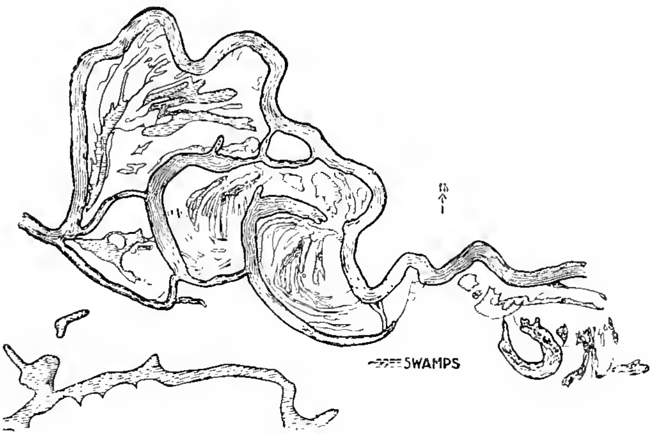


Fig. 76.—Map of the crescentic billabongs or backwaters of the Murray near Rutherglen.

this period, is shown on the accompanying sketch map, prepared from plans given me by Mr. Hardy. The thin black line represents the river as first surveyed in 1841. The survey of 1859 showed that the bend at A, above the junction at Whitehead's Creek was being increased by erosion of the left bank of the river, and by the accumulation of silt extending from the right bank across the whole of the original channel. Further north a great horseshoe meander

had been developed at B. By 1859 a shallow channel, used by the flood waters, had been cut across the most southern bend shown on the sketch map at C. The same survey showed two cut-off anabranches (D). and that the meander opposite Whitehead's Creek was being cut off by the formation of a new channel.

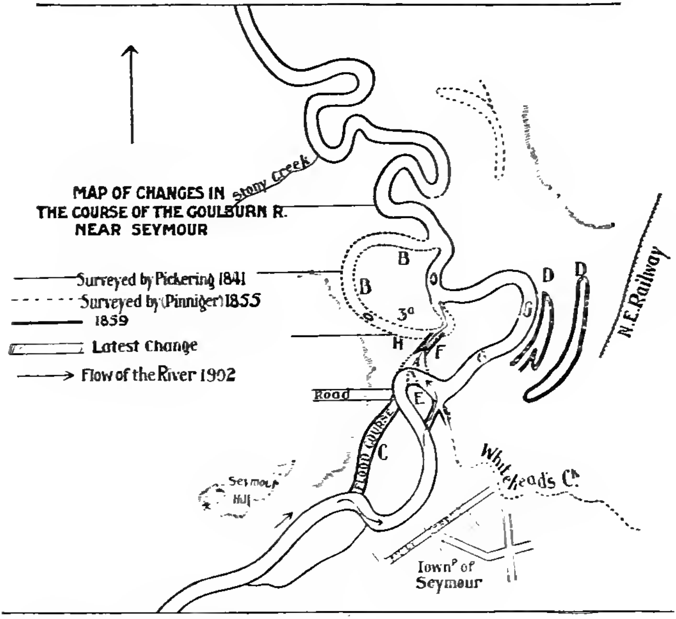


Fig. 77.—The Goulburn River near Seymour.

The great loop first shown in the survey of 1855 (B) as well as the earlier main channel of the stream, were then both being used by the river.

The great flood of 1870 appears to have been responsible for two further changes: it cut off the meander by Whitehead's Creek, leaving a "cut-off spur" as an island in the river (E); at the same

time, it cut through the narrow neck of land at F, turning the meander G into an anabranch. In consequence of this change, the direction of the flow of the stream between the island within the anabranch G and allotment 3A was actually reversed; whereas formerly the current flowed southward from the main stream into the loop B, the current in that channel, after 1870, flowed in the opposite direction. At the present time that channel is now being silted up at H, and thus the island, allotment 3A, will in time be joined on to the land to the south of it.

ii. River-bank Lakes.

The second set of the Murray lakes are of an essentially different origin,

The best representatives are in the chain of lakes from Kerang to Swan Hill. To understand their formation, we must consider a process of river-deposition, which is especially shown in rivers liable to periodic floods. When a river comes down in flood, it brings with it far more sediment than it could carry at its ordinary rate of flow. When the flood subsides, the silt is dropped on the river bed as a thin layer extending across the channel. As flood follows flood, successive layers of silt are laid down, until the river bed is gradually raised above the level of the surrounding country. In the well-known case of the Po, in Lombardy, the river now flows high above the plains. I once canoed down the Tana, in East Africa, when the flood had filled its channel brimful. The river was from 10 ft. to 15 ft. above the general level of the country, like an artificial aqueduct. The water was pouring through holes in

the banks, and depositing a layer of fertile silt over the flooded ricefields, which were themselves slightly raised above the level of the more distant plain. Two miles to the north and at a lower level was the River Ozi, which at one time had been a tributary of the Tana, and still flowed out through the old estuary of the Tana. But the Tana had been cut off from its old estuary by the raising of its banks. and reaches the sea eight miles to the west of its former mouth.

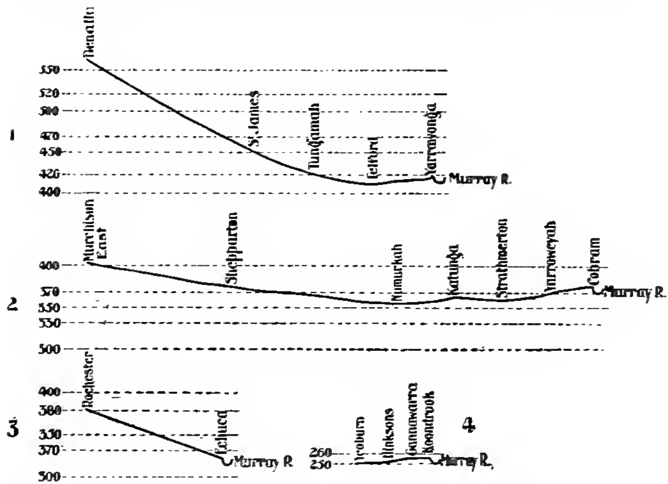


Fig. 78.—Sections across the South Slope and Raised Flood-Plain of the Murray River.

The raised flood plain is shown at the right hand ends of Nos. 1 and 2. In No. 3 there is no flood plain, the river having cut its way to the main southern slope towards the river. No 4 is all on flood plain.

The Murray also has been subject to periodic floods. which have raised its bed and banks above the level of the surrounding country. The raised position of the Murray banks is shewn by the levels of the neighbouring railways (fig. 78). Thus Yarrawonga, on the banks of the Murray, is 6 ft. higher than

Telford, seven miles away; Wahgunyah, on the Murray, is 6 ft. higher than Lilliput, nine miles to the south; Cobram, on the Murray, is 23 ft. higher than Numurkah, which is sixteen miles from the river. The relative heights of the Murray and the plains to the south are shown by the above sections (fig. 78). Except at Echuca the Murray bank is higher than the level of the adjacent country. In fact, the Murray is now flowing through an elevated flood plain. Accordingly, as the water of the tributaries cannot run up the slope of this raised flood plain, they are deflected

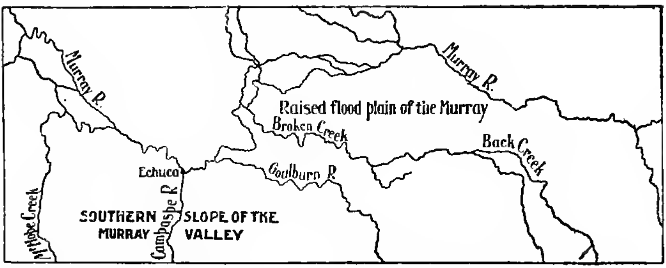


Fig. 79.—The westward deflection of Broken Creek and Goulburn River, and the Raised Flood-Plain of the Murray.

to the west so soon as they reach its edge. They flow along the line of the lowest land at the junction of the main slope towards the Murray from the south, and of the minor slope from the Murray bank.

This raised flood plain of the Murray begins after leaving Bundalong, where the Ovens joins the Murray. The three next tributaries, the Back, the Broken, and the Goulburn, are bent, almost at right angles, when they reach the edge of the raised flood plain. These rivers join the Murray only when, by a great bend to the south, it has cut through its own flood plain and

reached the edge of the main slope of its valley. At Echuca, as shown by fig. 79, the river has cut south to the beginning of the main left slope of the Murray Valley; so there is no raised flood plain, and the Campaspe enters the Murray without delay. On leaving Echuca the country on both sides of the river is lower, and the Murray again flows through a raised flood plain. Accordingly, the rivers

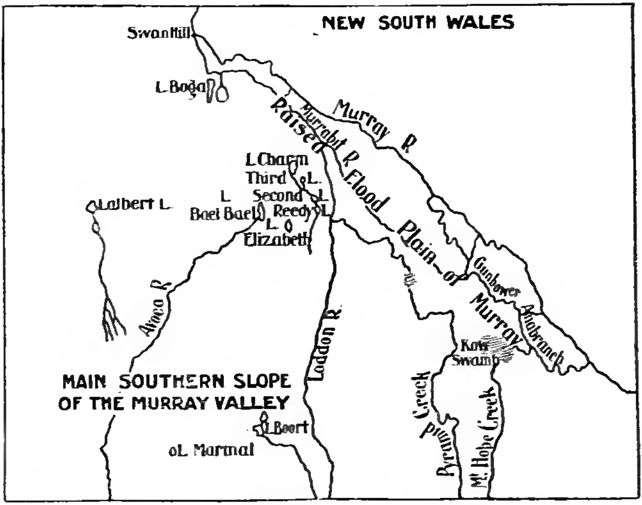


Fig. 80.—The westward deflection of Pyramid Creek and Loddon River by the raised Flood-Plain of the Murray.

are again deflected to the west: thus Mount Hope Creek flows as an anabranch, parallel to the main course of the river: Pyramid Creek and the Loddon are bent to the west. and flow beside the Murray, until they are forced to join it by the bluff at Swan Hill.

The flow of the rivers being thus obstructed, some of their waters collect in the adjacent depressions as lakes.

The north eastern branch of the Avoca is dammed back by the raised ground between it and the Murray, and expands to form Lake Bael Bael.

Lakes **Bael Bael, Lalbert,** and **Tyrrell** may belong to the group of lakes due to the flooding of the low-lying country behind the raised flood plain. The available evidence, however, in regard to these lakes is insufficient; but the lake chain along the Loddon, between Kerang and Echuca, including Reedy Lake, Lake Charm, Second and Third Lakes, and Lake Boga, certainly belongs to this category.

E. Mountain Tarns.

The last section of the Victorian lakes are mountain tarns. Such tarns occur in mountain regions, in small rock basins, and where a barrier across a valley dams up the streams. The dams that form these tarns have various modes of origin. The commonest dams are made of debris that has been dropped by the melting of a glacier; behind such a ridge, which is known as a "moraine," the water accumulates to form a moraine-dammed lake. A second common case is where a lake is due to a barrier made by landslips.

These mountain lakelets are rare in Victoria, because our rivers are so active, their fall giving them sufficient power to cut through any lake barriers in their valleys, and thus to drain the lake behind.

There are no high level lakes in Victoria with rivers flowing out of them, as there are in many countries where the rivers are younger.

The best Victorian representative of our mountain tarn is Lake Karng, near Mount Wellington. It lies in a hollow that is so difficult of access, that it is believed the aborigines were ignorant of the existence of the lake until about 1840. It was rediscovered by a stockman, named Snowden, in 1886, after which it was visited by Mr. A. W. Howitt, who has given a detailed description of it. Mr. Howitt revisited the lake, in company with Professor Dendy and Mr. A. S. Lucas, in 1890. The lake occurs in a steep valley on the northern slopes of Mount Wellington. Its level is apparently at about 3000 ft. above the sea. The lake is about 26 acres in area. It is formed by the damming up of the valley by a barrier, about 10 chains wide and one or one and a half miles in width, formed of huge blocks of rock. Mr. Howitt explains this dam as a glacial moraine, that is to say, a heap of boulders and stones brought down on the surface of a glacier, and deposited at its end as the ice slowly melted away. Professor Dendy, on the other hand, regards it as formed by a landslip; but Mr. Howitt has shown that there are difficulties in this landslip hypothesis. Mr. Lucas gives a third explanation of the lake, according to which the hollow above the lake dam was eroded by river action. The evidence quoted in support of each of the three hypotheses is unconvincing. The lake may be safely described as a mountain tarn formed by a dam across a mountain valley; but the origin of the dam is uncertain

Chapter VII.—THE EARTHQUAKES OF VICTORIA.

We have so far considered the geography of Victoria as due to the action of superficial agents, which derive their powers from the heat of the sun. We must now turn to the action of the deeper agents, which gain their power from the forces far below the earth's crust, and mainly from the heat of the earth's interior. The changes that are taking place in the deep-seated mass of the earth have a direct effect on the surface. The earth consists of two parts, a hard outer crust known as the lithosphere, and a central mass known as the centrosphere. The changes in the lithosphere due to processes going on in the centrosphere are governed by four main factors.

In the first place the earth is much hotter inside than on the surface; the internal heat is so great that the temperature increases, on an average, 1° F. for every 55 ft. of descent from the surface. If increase be continued at the same rate, then below the depth of 20 miles the rocks would be in a molten state, were they not kept solid by the enormous pressure of the overlying rocks. If that pressure be relieved, the rocks expand, and become liquid, and the gases imprisoned in them can escape. According to the rate at which the pressure is relieved, the gases will expand either violently, forming an explosion, or gently, forcing the rocks to rise towards the surface.

Secondly, the earth is slowly cooling. The earth's internal heat reaches the surface and passes forth into the utter coldness of space. The loss of heat is

imperceptible; but it was estimated by Haughton that the heat annually lost would melt a layer of ice a quarter of an inch thick over the whole surface of the globe.

Thirdly, as the earth cools, it shrinks in size. The earth's crust is hard and rigid, and, as the central mass contracts, it must leave part of the earth's hard shell insufficiently supported. Such unsupported areas of the earth's crust will sink, as the ground sinks on the falling in of the roof of an abandoned gold-mine. Wherever a block of the crust founders owing to the withdrawal of underground support, the sinking areas will be marked off from the adjacent country by lines of fractures and fissures. The sunken area will be separated by folds, where an area sags gently downward in the centre. In either case the subsidence will subject the rocks below it to heavy pressure. If the rocks be plastic through intense heat, and can reach fissures leading to the surface, then the rock material will be forced up and discharged in volcanic eruptions.

Fourthly, the earth's crust is not uniform in structure or in strength. Therefore, these subsidences will take place mainly along certain lines of weakness, and will avoid the more stable areas. Great regional depressions have formed the ocean basins, while the firmer blocks remain at a higher level as the continents. Moreover, the unequal yielding of the earth's crust has given the earth its somewhat irregular shape, which is not that of any regular figure and can be described only as a geoid—an earth-shaped body. Among regular forms the geoid is nearest to an oblate spheroid, but the two are essentially distinct.

The two chief geographical phenomena which result from the slow cooling of the earth and the interaction of the lithosphere and the centrosphere are Earthquakes and Volcanoes. An **earthquake** is the shock due to a movement in the earth's crust. The movement may be a vertical subsidence due to loss of underlying support, or a more or less horizontal thrust resulting from intense lateral pressure, forcing layers of rock over one another or bending them into folds; or it may be an oblique sliding movement, where a rock mass slips forward and downward, owing to the loss of lateral support by a subsidence. Another type of earthquake is formed by the shock of a great volcanic explosion.

The action of an earthquake, however it may be formed, is a wave-like movement of the particles of the earth's crust. We may compare the different types of earthquakes to the waves formed in a trough of water by various disturbances. If a pebble be dropped into the trough, the water below the pebble sinks downward, and a circular wave runs outward in all directions from the point where the stone strikes the water. An explosion below the surface of the water will cause a violent upheaval above the point of explosion, and a wave which spreads outward from the central disturbance. If one side of the trough be forced inward, then a long wave will be driven across the water. A long wave will also be formed, if the side of the trough be allowed to fall outward, leaving the water for a moment without its lateral support. These four types of waves illustrate respectively the earthquake waves formed by a simple subsidence, a

subterranean explosion, a lateral thrust, or the subsidence of a long belt of country.

The mode of formation and depth of origin of an earthquake can be inferred from the nature of its effects on the surface. Immediately above the place where an earthquake is formed, the disturbance is a violent movement up and down. Away from the centre the earthquake will strike the surface obliquely; and the angle beneath the path of the shock and the surface of the ground (known as the **angle of emergence**) will depend upon the distance and depth at which the earthquake originates. Places equally

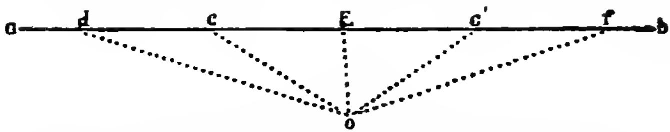


Fig. 81.—Diagram illustrating terms in connection with earthquakes.
a-b, surface of the ground; *o*, the origin or focus of an earthquake; *o E*, seismic vertical; *E*, epicentrum: *o d E*, *o c E*, &c., angles of emergence.

distant from the earthquake centre will be struck by the shock at the same angle; and, if the rocks of the region be uniform in character, the shock will be felt in such places at the same time, and the effects will be of the same violence. A line can be drawn through all such places; and the line usually forms either a circle or an ellipse round the point of origin of the earthquake. Lines passing through places of equal disturbance are called **isoseismic lines**. They will be concentric round the point where the earthquake originates, which is the **origin**. A line connecting that point to the surface is the **seismic vertical**; and immediately around the upper end of the seismic

vertical is the **meizoseismic** area, where the devastation is at its greatest. By the study of the isoseismic lines, the situation of the origin, and its depth from the surface, can be approximately determined. By the shape of the isoseismic lines, the nature of the disturbance which caused the earthquake can also be determined. A small meizoseismic area, in which everything is completely shattered, probably indicates a subterranean explosion. A well-defined area of intense devastation, from which the shock does not travel far outward, is probably due to local subsidences, as in the earthquake which devastated the island of Ischia, in 1883. Where the meizoseismic area is a narrow belt, along which the havoc is complete, the movement is probably due to a lateral thrust, as in the case of the Assam earthquake in 1897. Where the earthquake occurs along a long line, and the shock is gentle, the cause may be the movement of a strip of land along a line of subsidence.

In Victoria we fortunately have no historic records of earthquakes due to local explosions, or violent earth thrusts. But the sensitive earthquake recording instruments (seismographs) at the Melbourne Observatory feel the effects of these disturbances in other parts of the world. Thus, fifty minutes after the disastrous volcanic explosion at Martinique, on the 8th May, 1902, the instruments showed that, for nine hours, the ground of Melbourne trembled from the shock.

Victoria is, however, frequently disturbed by earthquakes of local origin, which are of considerable geographical interest. Unfortunately our knowledge of these earthquakes is very unsatisfactory, for though

records are now being taken with the most approved modern methods at the Melbourne Observatory, these records do not extend very far back. Moreover, in the study of earthquake phenomena, it is important to have accurate observations in several distant localities. For, if we know the precise moment at which a shock is felt at many different localities, we can determine its direction of movement.

The records of Victorian earthquakes are scanty. In the early history of the colony we naturally know only of the most severe shocks. The first recorded was in April, 1841 ; another occurred on the 28th April, 1847, when, according to McCombie's "History of the Colony of Victoria" (1859, p. 124), "Melbourne was severely shaken; the panic was very considerable, and the Supreme Court was hastily adjourned. The shock was very severely felt in the lower portion of Melbourne, particularly about Elizabeth Street." A third earthquake, also recorded by McCombie, occurred on the 17th September, 1855, at 2.52 a.m. Brough Smyth stated that "the shock was felt over a very extensive area, apparently conforming rudely to the line of the coast range." This suggestion of Brough Smyth's is interesting, as so many of our later earthquakes show the same general distribution.

The *Argus* published the following fuller account of the 1855 earthquake :—"At 2.55 the severe shock of an earthquake was felt in Melbourne. The shock lasted about one minute. The rocking motion was very distinct, and caused slates and windows to shake. Accounts of the nature of the shock differ considerably. Some describe it as a rolling motion;

others were sensible of a heaving and violent vibration. In some large hotels bells rang, windows rustled, and crockery and kitchen utensils clashed. The thick walls of the Benevolent Asylum experienced some damage from vibration. In Brighton and St. Kilda the shock (some say more than one) was severely felt. The general opinion appears to be that the line of action was from east to west.

In Boroondara, one of the buildings rocked to and fro: the shock came from the east, and rolled off to the west, causing vibration to be felt north and south. A peculiar noise was heard, similar to the knocking of two great stones in a bag, as if the upper rocks were striking against the lower. At Hawthorn windows were shaken violently. The chimneys of a house were split. At the Boroondara Stores every bottle and box rattled. Plaster fell from the ceiling in a house on Gardiner's Creek. A large iron storehouse on the Yarra was considerably shaken. A feeling of seasickness was felt. The period of the duration of the shocks was from three to five seconds. The time at which the phenomenon was noticed appears to have been 13 minutes to 3 a.m. At Gisborne, a smart shock was felt at 2.52 a.m.: the motion was not a heaving one, but simply a tremor or violent shaking, which lasted 30 or 40 seconds. The shock cracked the ceiling of a wooden cottage. At St. Kilda the same motion was felt.

In Victoria Street, North Melbourne, there were two shocks; the mean time of the first shock was at 2.46, and of the second 2.48. The first shock travelled from west to east, the second went from W.S.W. to E.N.E.; it was more powerful, but of

shorter duration, and caused more distinct oscillations. There was a heaving motion, that was scarcely perceptible, followed by short, quick, and horizontal oscillations, similar to gravel being shaken backwards and forwards in a tray. A sound was heard as though the house was being drawn bodily over a platform of boulders. It was concluded from the various reports, that either the centre of disturbance was of large extent, or there were two *foci*, somewhere between 140° and 143° east longitude, and 37° and 38° 30′ south latitude."

A list of earthquakes felt in Victoria during 1884-91 is published in the Reports of the Australasian Association for the Advancement of Science (Vol. IV., 1893, pp. 208-212) ; 56 shocks are included in this list. The great majority of them were recorded by the lighthouse keepers; and thus the apparent greater frequency of earthquakes along the coast than inland is perhaps somewhat exaggerated.

Owing to the kindness of Mr. Baracchi, I have been able to go through the earthquake records at the Melbourne Observatory; they supplement the published lists by notes as to the direction in which the shocks appeared to be travelling. Of the total series of 56 earthquakes recorded on this list, 42 were felt at Gabo Island, four at Omeo, five at Wilson's Promontory, seven at Melbourne, one at Kilmore, and three at Bright and Beechworth. Comparatively few of these shocks were noticed at more than one locality.

The first that was widely reported occurred on the 19th September, 1884, of which there are six records; it was felt at Gabo Island at 8.35 p.m., at Omeo at

8.30 p.m., Cape Schanck at 8.29 p.m., Lakes Entrance at 8.30 p.m., Wilson's Promontory at 8.30 p.m., and Port Albert at 8.35 p.m. The record of the times at which the shocks were felt are apparently unsatisfactory; but the fact that they were felt at Cape Schanck, Lakes Entrance, Wilson's Promontory, and Port Albert at approximately the same time suggests a shock coming from the south, and striking the coastline approximately at right angles. The shock at Omeo may have been either due to a distinct earthquake, or, more probably, there is an error in the recorded time.

On the 10th January, 1885, there was a shock which affected Mornington. It was felt at Mornington at 3.15 a.m., and was said to come from the south or south-west; it was recorded at Cape Schanck at 3.18 a.m., at Berwick at 3.20 a.m. (where it was apparently travelling from south to north), and at Melbourne at 3.25 a.m., where it was recorded as coming from the north-east. If the times are reliable, one would expect the shock to have started from near Mornington and two waves to have passed south and north. On the 13th May, 1885, a severe shock was felt at Gabo at 9.35 a.m.; it lasted one minute and travelled from south to north; it passed Wilson's Promontory at 9.27 a.m., where it lasted 48 seconds, and was there coming from south-east; it struck Lakes Entrance at 9.30 a.m., Warragul at 9.31 a.m., Bairnsdale 9.29 a.m., Stratford at 9.30 a.m., and Melbourne at 9.30 a.m., Beechworth and Bruthen 9.28 a.m., and Bendoc 9.35 a.m. It was also felt at Flinders and in Tasmania. The times cannot all be reconciled; but it would appear to have been a shock coming from the south,

and travelling north, reaching Wilson's Promontory first, Lakes Entrance, Bairnsdale, Gabo Island, and Melbourne next, and Warragul still later. But according to the times given, the shock was at Bairnsdale a minute later than Lakes Entrance, whereas the reverse would have been expected.

On the 11th September, 1885, there was an earthquake, felt at four places. It was apparently formed in Bass Strait, for the shock was felt first at Gabo at 7.5 p.m., and Wilson's Promontory at 7.7 p.m., and here its approach was heralded by a rumbling noise from the south-east, and the shock lasted for six seconds. Passing thence northward, it reached Omeo at 7.10 p.m., while it was last felt westward at Flinders at 7.18 p.m. In Tasmania, the shock was recorded at Launceston at 7.7 p.m.

On the 8th October, 1885, there was an earthquake in the Bright and Beechworth district, which was felt first at Bright at 9.36 a.m.; southward, it was recorded at Omeo at 9.37 a.m., and northward, it reached Beechworth at 9.40 a.m., and Tallangatta at 9.47 a.m. The centre was therefore probably somewhere south of Bright.

On the 2nd August. 1886, there occurred a shock in the extreme east of Victoria, which shows that the frequency of earthquakes at Gabo Island is due to the fact, that it is disturbed by shocks from the north and north-east, as well as from the south. Gabo Island then felt a shock from the north-east at 8.55 p.m., while Eden felt a shock from the south at 8.45 p.m. It is probable that this shock arose on the steep eastern shore of Australia, a little north of Gabo.

On the 7th June, 1891, two earthquake shocks were felt in the Port Phillip area. The first was a little after two in the afternoon; it was recorded at Melbourne at 2.4 p.m.; at Queenscliff (travelling from south-west to north-east) at 2.6 p.m.; at Elaine, near Ballarat, at 2.6 p.m.; at Myrniong, near Bacchus Marsh at 2.7 p.m.; and at Sorrento at 2.8 p.m. This shock was especially severe at Rosebud, near Dromana. If the times are reliable, the shock in this case must have travelled from north to south, and may have arisen a little west of Melbourne.

For information regarding earthquakes after 1891, I am indebted to Mr. Baracchi, who has given me the opportunity of examining the earthquake record book of the Observatory. On 27th January, 1892, a severe shock was felt at 2.30 at Little Yarra; at 2.55 a.m. at Gabo Island; at 2.45 a.m. at Cape Everard, where the observer stated that the shock travelled from south-west to north-east. At Wilson's Promontory two shocks were felt, one at 2.40 a.m. and one at 2.50 a.m.; they were travelling from the south-west. This earthquake was recorded as having shaken Welshpool at 3 a.m., Foster at 2.35 a.m., Grant at 2.30 a.m., and Omeo at 2.45 a.m. At the same time a severe shock was widely felt in Tasmania, as at Hobart, from 2.48 to 2.50 a.m. On the north coast of Tasmania, it was felt at Emu Bay and Cape Portland, both at 3 a.m., at Circular Head at 2.45 a.m., at Beaconsfield at 2.50 a.m., at Georgetown at 2.55 a.m. Further inland two shocks occurred at Launceston, one at 2.49 a.m., and one at 3.4 a.m., and a shock was recorded at Deloraine at 2.50 a.m. On the east coast shocks were felt at Falmouth at 2.45 and 2.50 a.m. This earthquake has

an exceptionally wide number of records, as it shook practically the whole of Tasmania. In Victoria the shocks were mostly felt on the south coast. The times reported are inconsistent, and there was no general agreement as to the supposed direction of travel. The lighthouse keeper at Cape Everard reported it as coming from the south-west at 2.45 a.m., and the lighthouse keeper at Gabo Island felt it coming from the east-south-east, and going westward at 2.55 a.m. The most probable explanation is that these shocks originated on a long east and west line, as a series of slight movements extending probably over half-an-hour. Hence the shocks felt at Everard and Gabo were probably due to different incidents in one series of movements.

At about midnight on 23rd December, there was a slight shock felt over the Mornington Peninsula. Four distinct shocks were felt at Mount Martha, ranging from one minute past midnight to a quarter to one. At Cape Schanck there was a slight shock at six minutes past midnight. It was recorded at the same time at Mount Martha. At Flinders a shock was felt exactly at midnight, apparently corresponding to the earlier one at Mount Martha. At Mornington two shocks passed, of which one made a loud noise at 12.15 a.m.

The most pronounced earthquake of recent years in Victoria, happened on the 10th May, 1897, at about 3.30 in the afternoon. It was felt over most of the south-east of South Australia and of southern Victoria, west of Melbourne. It was most severe at Kingston, on the South Australian coast. The records of this earthquake in Western Victoria include Casterton at

3.25 p.m.; Stawell at 3.26 p.m., where windows and crockery were broken, pieces of plaster were knocked off the ceiling, and the vats in the Cyanide works over-flooded; Ararat at 3.27 p.m.; Donald at 3.22 p.m. (the shock travelling in a north-easterly direction);

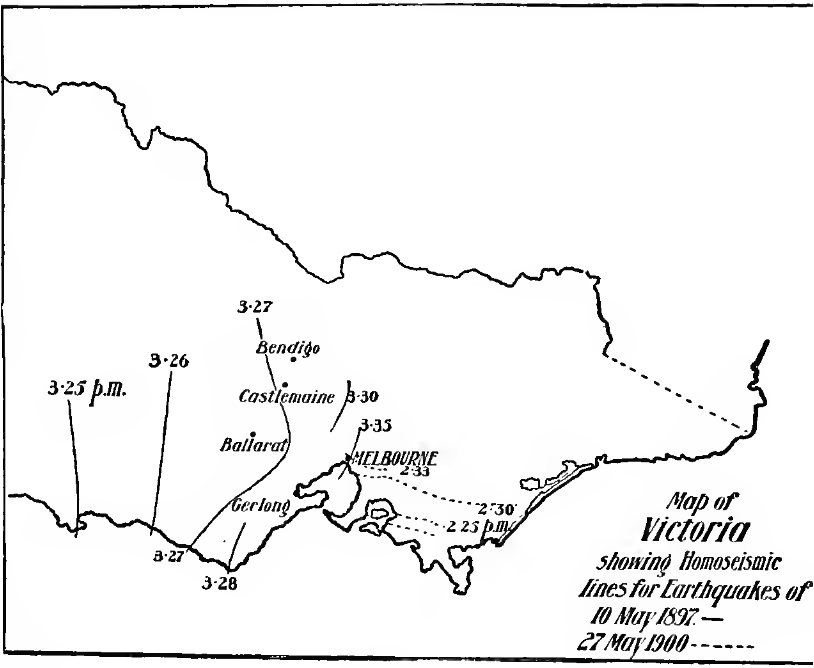


Fig. 82.

Serviceton 3.23 p.m.; Cape Otway at 3.28 p.m.; Meredith 3.27 p.m.; Inglewood 3.27 p.m.; Bacchus Marsh 3.27 p.m.; Mildura 3.27 p.m.; Portland 3.25 p.m.; Warrnambool 3.26 p.m.; Merino 3.30 p.m.; Seymour 3.30 p.m.; Stuart Mill 3.30; the seismograph at Melbourne Observatory 3.35. The shock at

Kingston was severe; it did serious damage to an hotel, it wrecked several houses, injured some of the inhabitants, and caused subsidences of the ground in two or three places, to the depth of three feet. At Port Caroline fissures eight or nine feet deep were formed, and water was shot upward to the height of several feet above the ground; several wells were filled with sand, forced up from below, while the sand on the sea floor was also jerked upward, making the sea muddy. The people were so alarmed that for several days afterwards they lived in tents. This earthquake must have been formed by a subsidence on the floor of the Southern Ocean, to the west or south-west of Kingston.

On the 23rd November, 1899, a slight shock occurred in the Port Phillip basin. It was recorded at the Observatory at 5.16 p.m., and at the National Bank at 5 hours 15 minutes 10 seconds. It was felt at 5.15 p.m. at Brunswick, Abbotsford, Cowes, Cape Otway, and Queenscliff; the lighthouse keeper at Cape Schanck felt it at 5.20 p.m. It was recorded at Dandenong at 5.20. It was most severe at Pakenham, where it is reported as occurring at 5.5 p.m., Fern Tree Gully 5.12 p.m., at Cheltenham 5.31 p.m., and at Gembrook. One observer stated that the shock was travelling from the south-east to north-west. The times are again inconsistent, but it is not safe to conclude that the observers, who were so sharply shaken at Pakenham, could have made a mistake of ten minutes in their time; so it is probable that the shock had a double origin, one centre of disturbance being in the Pakenham district, while a supplementary shock happened in the Port Phillip

basin, ten minutes later. Probably the main shock came from the south, passing first from Cape Otway, Cowes, and Queenscliff at 5.15 p.m., and reaching Melbourne ten seconds later.

In the earthquake records for these eighteen years, from 1884-1901, the Kingston earthquake only has given reasonably satisfactory evidence ; and even in that case the times recorded are somewhat inconsistent. Nevertheless, the evidence as a whole is suggestive. The records show the prevalence of earthquakes along the coast line, and the tendency of some of the shocks to strike fairly distant points along the shore at about the same time. The simplest explanation of most of these shocks is that they originate in Bass Strait, either by vertical subsidences of part of the floor, or by a slip of part of the sloping sea bed. Movements also appear to be in progress east of Gabo Island, and in St. Vincent's Gulf. Some minor earth movements also appear to have taken place on the floor of Port Phillip. The Alps between Omeo and Bright appear to be another earthquake centre.

The data for the earthquakes of 1900 and 1901 are tabulated in Appendix No. 2. The object of this chapter will be best fulfilled, if it secures more careful local records of the exact time at which earthquakes are felt, the direction in which they appear to be moving, and the amount of vibration or damage which they occasion.

The satisfactory study of the earthquakes of any country requires the use of a seismograph (an instrument which records very delicate earthquake shocks) in three or more distant localities. In Victoria there is

at present only one seismograph, which is at the Observatory in Melbourne, and its records date back only to 1901. The intensity of an earthquake can, however, be roughly estimated by personal observations. The variation in the intensity of the earthquake shocks, as thus judged, is measured by what is known as the Rossi-Forel scale of intensity. It was originally proposed by an Italian observer, Rossi, and was modified by the Swiss geologist, Forel. The scale of intensity is as follows:—

No. I.—Recorded by a single seismograph, or by some seismographs of the same model, but not by different seismographs of different kinds; the shock felt by an experienced observer.

No. II.—Recorded by seismographs of different kinds; felt by small number of persons at rest.

No. III.—Felt by several persons at rest; strong enough for the duration or the direction to be appreciable.

No. IV.—Felt by persons in motion; disturbances of moveable objects, doors, windows, cracking of ceilings.

No. V.—Felt generally by everyone; disturbances of furniture and beds; ringing of some bells.

No. VI.—General awakening of those asleep; general ringing of bells, oscillation of chandeliers, stopping of clocks; visible disturbances of trees and shrubs. Some startled persons leave their dwellings.

No. VII.—Overthrow of moveable objects, fall of plaster, ringing of church bells, general panic without damage to buildings.

No. VIII.—Fall of chimneys, cracks in the walls of buildings.

No. IX. — Partial or total destruction of some buildings.

No. X. — Great disasters, ruins, disturbances of strata, fissures in the earth's crust, rock-falls from mountains.

According to this scale, Kingston experienced a shock of the intensity of No. IX., while the recent Warrnambool earthquake of April, 1903, would probably be slightly over No. 7.

Chapter VIII.—THE EXTINCT VOLCANOES OF VICTORIA.

The volcanic history of Victoria belongs rather to geology than to geography; but the last period of volcanic activity added such conspicuous features to the scenery, and such wealth to the soil, that it must be considered in a geographical account of the State.

According to mediæval notions, a volcano was a burning mountain, giving off smoke and flame, and due to subterranean fires. This definition, though it still lingers in use, gives an entirely wrong idea of the nature of a volcano. Burning is essentially an act of combustion, involving the consumption of one material by its combination with another, which is generally the oxygen of the atmosphere.

A volcano does not burn, and the features popularly identified as smoke and flame are quite different in their nature. The material that is generally regarded as smoke is a great column of steam, darkened by volcanic dust. What is regarded as flame is the reflection of the molten lava of the volcano upon the

clouds above. Flames do occasionally occur; but they are small and unimportant, and can be recognised only by the aid of the spectroscope. A volcano is not even necessarily a mountain; it is, on the contrary, a passage by which the surplus materials from the interior of the earth are discharged to the surface. The eruption is not the result of subterranean fires, but of the internal pressure, which forces the rocks buried deeply in the earth's crust to flow to the surface, if a way of escape be opened to them. A volcano is therefore rather a hole in the ground, than a mountain. As volcanic action proceeds, a pile of the ejected material is formed around the volcanic vent, forming a volcanic hill or mountain. But this mountain is the result of the volcano, and not the volcano itself. It is no more the volcano, than the funnel of a locomotive is the locomotive itself.

Volcanic hills are very different in their structure from ordinary mountains. They are built up, layer by layer, of the material ejected from the volcanic vent. There are three main kinds of volcanic hills. The first consists of layers of lava or molten rock, poured in streams from the volcanic vent, and layers of small fragments of the lava which have been blown into the air, and fallen around the vent. These fragments form beds of volcanic ash, separating the successive lava flows.

A second kind of volcano is built up of loose, porous material known as volcanic scoria; some cones consist wholly of this material, and they are known as **scoria-cones.**

The third type of volcanic hills is the great **lava dome.** The lava has quietly welled forth from a

volcanic vent, without any of the explosions, which produce volcanic tuff and scoria.

A volcanic hill always surrounds the **vent** of the volcono, or the mouth of the channel which leads down to the subterranean regions. The part of this channel below the vent is known as the **throat** or **neck** of the volcano. Around the vent there is

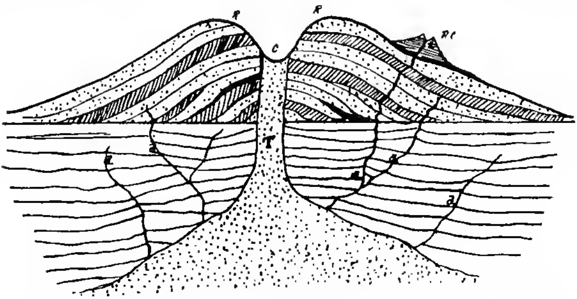


Fig. 83.—Section through a composite volcano, of alternate beds of volcanic scoria and lava.
T, neck of volcano; *C*, crater; *R*, crater rim; *R C*, secondary crater *d*, dykes.

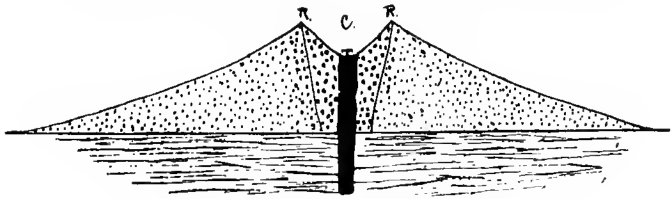


Fig. 84.—Section through a Scoria-cone.
C, crater; *T*, vent of summit of the neck of the volcano.

generally a ridge, which is typically circular. This ridge encloses a cup-shaped depression, or **crater**. Typical craters are very deep in proportion to their diameter. In other cases there is, above the throat of the volcano, a wide and comparatively shallow depression. Such depressions are known as **calderas**,* and they are due to the sinking of their floors.

*Anglicized as "caldro s."

Volcanic craters have generally a complete rim; but in some cases the heavy lava rises in the crater, until its weight is so great, that it bursts through one wall of the crater, and flows ont through the breach. Such craters are known as **breached craters** (*eg.*, fig. 88).

In other cases the craters are not circular, as two vents occur close together, or, as is more nsually the case, by the closing of the first volcanic vent by a plug of solid lava, and the opening of another vent beside it. In such cases there may be two incomplete craters resting against one another, or the second crater may be formed upon the wall of the older crater.

The **materials** which are ejected from volcanoes consist of molten rock, known as lava, rock fragments, steam, and various gases. The most important material is **lava.** This is molten rock, which has been forced from some depth below the earth's surface, and flows out in streams from the vent. Lavas differ greatly in their chemical composition, appearance, and structure. If a lava cool very quickly, it may form a natural glass, such as obsidian. If it cool slowly, it may form a compact rock composed of a taugled mass of different minerals. If a lava cool comparatively slowly, while steam has been escaping from it, then it will contain many holes, kuown from their method of formation as **gas cavities.** If a lava saturated with steam cool slowly, then it may form a glassy rock so full of cavities, that it will float on water, as **pumice.** A rock formed under similar conditions and full of gas cavities, but in which the walls of the cavities are composed of stony, instead of glassy lava, is said to be **scoriaceous,** from the Latin word meaning dross.

The surface of a lava flow varies with the chemical composition of the lava, and the rate of its solidification. When the rock has flowed slowly, the material is half viscous, like thick treacle or pitch; it cools in rounded surfaces, which often surround great spheroidal masses that roll over one another. Or a viscous lava crust may form long, narrow bands, which roll over one another and solidify in rope-like coils, producing the well-known **ropy structure.** In other lavas the scoriaceous structure prevails. The surface is pumiceous or scoriaceous. Some lavas consolidate in irregular rough blocks, so that the lava flows look like piles of lava blocks.

The contrast between the lavas which consolidate in rounded surfaces and those in rough blocks, is especially well shown in the Sandwich Islands. The names there given to them, namely pa-ho-e-ho-e for the former, and the a-a for the latter, have been somewhat widely adopted by geologists. But Professor Bonney thinks the two types equally well described by the English terms slaggy for the pa-ho-e-ho-e, and scoriaceous for the a-a.

The fragmentary materials ejected from volcanoes consist of the following varieties.* **Volcanic scoria**

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* The terms for the fragments ejected from volcanoes are somewhat differently used. They are here accepted as defined by Professor Judd. He defines scoria as "the large, rough, angular, cindery-looking fragments. When reduced to the dimensions of a marble or pea, they are usually called by the Italian name of 'lapilli.' The still finer materials are known as volcanic sand and dust."

He defines tuff as the finely divided materials, which, owing to the storms of rain which frequently accompany volcanic eruptions, "descend in the condition of mud, which flows evenly over the surface of the growing cone, and consolidates in beds of very regularly stratified 'tufa' or 'tuff.'"

The distention, by the escape of steam, of a mass of lava, which consists of crystals and a liquid magma, "gives rise to the formation of rough, cindery-looking material, to which the name of 'scoriæ' is applied."

(or ashes) consists of small fragments, which have been torn off the lava by explosions of steam. The fragments of volcanic scoria are said to be the size of nuts; they thus vary from the size of a cocoanut down to the size of small Barcelona or monkey nuts.

Agglomerates are also composed of fragments of lava, but the fragments are very much larger than in volcanic scoria. In some cases they consist of irregular blocks of lava, three or four feet in diameter. Agglomerates are formed by violent volcanic explosions.

Volcanic dust is the fine material ejected from volcanoes; it rises in a great cloud above the crater, and is carried to enormous distances by the wind.

Volcanic tuff consists of volcanic material which occurs in layers. Volcanic tuffs are of three different kinds:—(1) Volcanic material which has fallen around a volcanic vent, and been deposited in beds, owing to the action of rain; (2) volcanic material which has fallen into water, and thus acquired a well-marked horizontal bedding; in this case, if the material has fallen into the sea, the beds may contain marine fossils, if into a lake, they may contain freshwater fossils; (3) a bed of rock formed by the redisposition of fragments of volcanic rocks, especially scoria and dust, mixed with sand and pebbles.

Volcanic bombs are fragments of lava which have been shot up into the air, and, owing to their rotation while passing through the air, have taken a rounded form. Typical volcanic bombs are oval in shape, with a laminated structure, and generally have a small tail at either end.

Steam is the most important of the gases discharged from volcanoes. The steam may have been formed from the surface waters, with which the lava has come in contact; or it may be, in part, an original constituent of the lava, which has been brought up with it from the interior of the earth. Among other gases evolved, are carbonic dioxide, hydrochloric acid, sulphuric acid, hydrogen, etc.

Ejected blocks are fragments of rocks torn from beneath the volcano, and carried up with the lava. When they have been torn from the platform immediately below the vent, the blocks retain their original characters, and are but slightly altered. Where they have come from considerable depths below the surface, and have been carried for some distance in the lava, they are so altered that their original characters are destroyed. Some of the ejected blocks represent the deep-seated rocks, from which the lavas have been derived.

Volcanic eruptions sometimes take place by the quiet welling forth of lavas, which build up great lava domes. At other times volcanic eruptions are accompanied by violent volcanic explosions, such as the explosion which shattered the volcano of Krakatoa in 1884, or the two explosions which devastated parts of the islands of St. Vincent and Martinique in 1902.

Volcanoes may continue in action almost continuously for long periods of time. Thus the volcano Stromboli, on one of the Lipari Islands, was so regular in its action, that it was known as the lighthouse of the Mediterranean; it has been stated that it has kept up two eruptions within every quarter-of-an-hour for the last two thousand years. It has

however, during recent years had a period of quiescence.

Intermittent volcanoes have violent eruptions, separated by long periods during which the volcanoes are **dormant** or inactive. Thus Vesuvius had been so long inactive, before its first recorded eruption, that its volcanic origin was unknown, and the crater was used as a fortress during the Servile Wars. Its first recorded eruption was in A.D. 79, when it destroyed the town of Herculaneum by covering it with a stream of volcanic mud, and Pompeii by burying it beneath a rain of volcanic dust. Vesuvius has, since then, had long periods of alternate inaction and of volcanic activity. In the Middle Ages it remained dormant for long periods, especially during the years between about 1200 and 1631.

Extinct volcanoes are those in which volcanic action has permanently stopped.

The chief cause of volcanic action has been explained in the previous chapter; it is due to the contraction of the earth's crust, forcing the surplus materials from the interior through vents and fissures to the surface. In some cases volcanic action may be due to the explosive force of steam. Steam is given off from most volcanoes in enormous quantities; and as most existing volcanoes are situated near the sea coast, it is thought that volcanoes are due to the sea water finding its way down through cracks in the earth's surface, and coming in contact with masses of intensely hot rock. The heat makes the water explode into steam, and rends an opening to the surface, through which the lava escapes. But volcanoes are also known far from the sea, or even

from large bodies of water. Thus, on the high plateaus of eastern Africa, there are enormous tracts of land far from the coast, and there is no evidence that they were near the sea when the volcanoes were in eruption. Moreover, two small volcanoes and many steam vents are still active there. In other cases volcanoes which are close to the sea, as in the Sandwich Islands, give off comparatively little steam.

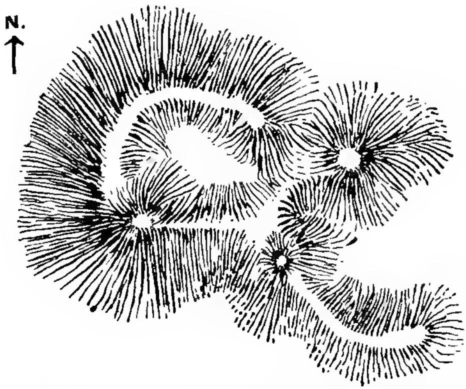


Fig. 85.—Mt. Mary, a worn volcanic crater on the plains, eighteen miles west of Melbourne.

Violent explosions, however, are probably always due to the discharge of steam.

In Victoria there are the remains of volcanic action belonging to many distinct periods; but it is only the last period of volcanic activity that we need consider. Its action was limited to western Victoria, extending from Melbourne to beyond the South Australian frontier; it ranged from Camperdown on the south, across the whole width of the Great Valley of Victoria, across the Central Highlands, and down the valleys of

the Loddon, Campaspe, and Coliban. The most conspicuous relics of this volcanic action are the

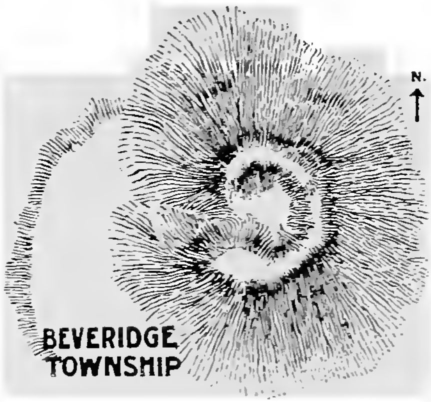


Fig. 86. Map of the worn volcanic crater at Beveridge.

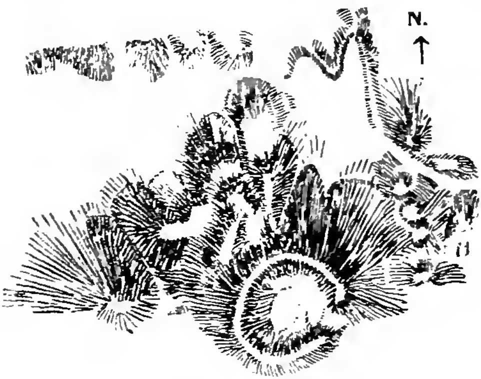


Fig. 87.—Map of Mt. Franklin, near Daylesford. A well preserved volcanic crater.

numerous volcanic hills, scattered over the western plains or on the highlands near Ballarat, and along the valley of the Loddon. Some of these volcanoes

are, geologically speaking, of quite recent date, and are still in excellent preservation. Those near Melbourne, such as the hill known as Mount Mary, which can be seen across the plains due west of Melbourne, or Aitkin's Hill, north of Broadmeadows, are less well preserved; most of the loose volcanic scoria and tuffs have been washed away, and the plug

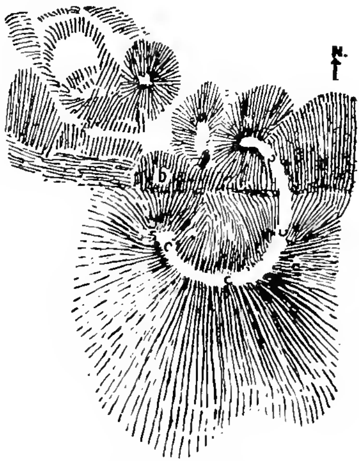


Fig. 88.—Map of Mt. Warrenheip, near Ballarat. A breached crater. *c c*, the crater rim, *b*. the breach, through which a lava flow has gone to the N W.

of lava, which filled up the throat of the volcano, has been left as a hummock rising above the plain. Such worn-down volcanic craters are known as **volcanic necks.**

Elsewhere the volcanic hills have been less altered by time. Some of them have perfectly-preserved craters, such as Mount Franklin, near Daylesford, and Mount Noorat, near Terang. Mount Warrenheip, near Ballarat, presents a good illustration of a **breached**

crater, the northern wall of the crater having been broken away by the weight of the lava, which has flowed out through it. Mount Elephant is another well-marked breached crater. **Compound craters** are represented by Mount Buninyong, near Ballarat. The whole of the southern side of the original crater wall was destroyed by the opening of a second volcanic

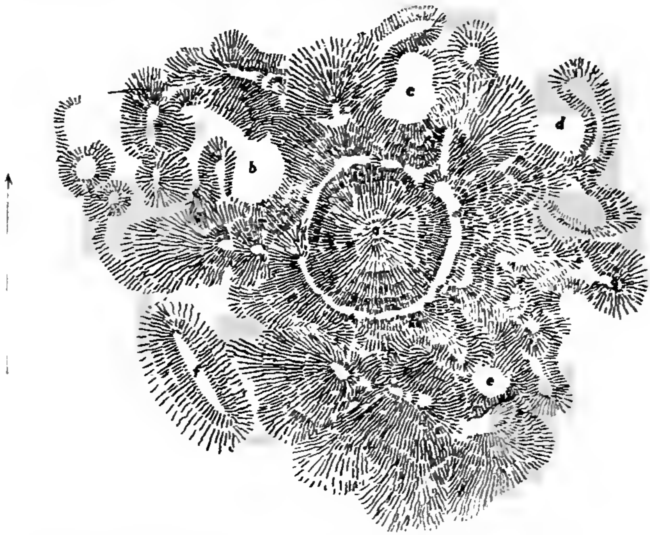


Fig. 89.—Map of Mt. Noorat, a compound volcano including a large central crater and four small secondary craters.

Scale. 4 in—1 mile (From a survey of the Lands Department, Victoria, revised by D. J. Mahoney)

a, main crater. *b c d e*, secondary craters *f g*, scoria cones. *d*, breached crater.

vent, a little to the south of the original vent. Mount Noorat, near Terang, has a group of five craters. The largest and central crater is still perfect, though its rim must once have been much higher. Four secondary craters lie upon the flanks of the central cone (Fig. 89).

Fig. 90.—View inside the Crater of Mt. Noorat.

The volcanic hills in Victoria are built up of the usual varieties of volcanic materials. The northern flank of Mount Leura and Shadwell near Matlock, both include beds of volcanic scoria, of which good sections are shewn in quarries for road metal. Among the volcanic scoria of Mount Leura are many well-formed volcanic bombs.

Beds of volcanic agglomerates are found on many of the volcanic necks, and occur, amongst many other places, at the head of one of the tributaries of the Parwan, south of Ingliston. Most of the volcanic necks are now composed almost entirely of lava, but this is probably because the fragmentary materials have been removed. But the great masses of Mount Macedon and Mount Dandenong were probably formed by domes of lava, while the fragmentary materials in them were always insignificant in amount. These mountains, however, were formed before the last period of volcanic activity.

The broad down-shaped hill to the south-west of Camperdown, and the plains between Terang and Noorat, are formed of re-deposited, bedded tuffs. The low cliffs around Lake Terang, and a bank on the road leading to Gnotuk Park, near Camperdown, show the bedding, which indicates that the materials were laid down under water.

The lava flows from the recent Victorian volcanoes are generally of the slaggy type. The lavas that escaped were fairly liquid so that they often ran to a considerable distance from the volcanic vent; the limits of the lava streams are however sharply marked out.

Where the surface of the lava has not been much altered by the weather, it often shows well-developed ropy structure. In some lava streams, although most of the rock is compact, it may suddenly become full of gas cavities, because it has passed over a small pool or damp ground, the steam from which has filled the overlying lava with gas cavities.

Fig. 91.—A lava flow of basalt boulders, (*a a* type). Mt. Porndon.

A well-marked development of the scoriaceous or a-a structure is shown in the lava streams, which have come from Mount Porndon, near Lake Purumbete. Streams from this crater flowed northward almost to the shore of Lake Korangamite, and south-westward nearly to Lake Porndon. The crater stands in the middle of an area of about 50 square miles, which is covered by ridges of piled lava blocks. These ridges

are so rough and boulder strewn, that they are known as the Stony Rises, and the land is practically valueless for agricultural purposes.

The view has been expressed that the whole surface of the south-western plain of Victoria is composed of one continuous sheet of basalt; if that were so, the Victorian basalts would approach in extent the great lava sheets of Idaho and the adjacent states of North

Fig 92.—View from Mt. Porndon across the Stony Rises (lava flows of the *a a* type) to Lake Korangamite.

America, or the lavas known as the Dekkan traps in India. These lava sheets are of such enormous extent, that it has been maintained that they could not have been erupted from ordinary volcanic vents, but that the lava flowed from long open fissures. They have, therefore, been called **fissure eruptions**; and the lavas of south-western Victoria have been regarded as due to this mode of eruption. When the western

Fig. 93.—Mount Buninyong from Mount Warrenheip.

plains are examined in detail, however, it is found that the lavas cover only a part of the country. The lava, which is the variety known as basalt or bluestone, has poured out from each vent in all directions. The eruptions have formed an irregular, circular sheet of lava around each vent; these sheets are separated by great tracks of alluvium, deposited in the swamps, that lay in the depressions between the lava flows.

The extensive mining operations in Victoria have revealed, in many places, the nature of the ground beneath the lava flows. If they had been formed by fissure eruptions, then many of the lava fissures ought to have been found. But I know only four instances where such fissures have been found, and at only one of these was there any proof of its connection with a volcanic vent.

The geological map of Victoria shows some long belts of lava, running down the valleys on the northern side of the Central Highlands, as along the Loddon and its tributaries. At first glance it might appear, either that the basalt had flowed a great distance from its point of eruption, or else, that the basalts had been discharged from fissures. Study of these lava belts show that they have been formed by flows from many different volcanic vents, uniting into a broad continuous sheet of lava.

How long ago the last Victorian volcano was in eruption is uncertain. Some of them, owing to their perfection of preservation, must have been formed in comparatively recent times. But the size of the trees which have grown upon even the best preserved of the craters, shows that they have not been in eruption for several centuries past. The aborigines are said to

Fig. 94.—The crater of Mt. Leura. (The town to the left is Camperdown).

have had traditions of some of the volcanoes having been in eruption; but the evidence on this question is not convincing. The legends, which are the best authenticated, contain statements which suggest that the stories were invented by the natives, and do not represent actual observation. Thus one tradition refers to an eruption at Mount Buninyong; whereas geological evidence would suggest that that mountain is much older than Warrenheip or Mount Noorat. According to another reported native legend, Mount Leura was formed from the material which originally filled the basins of Lakes Bullenmerri and Gnotuk; but this tradition is in direct conflict with the geological evidence, and accordingly gives no support to the view that the natives ever witnessed volcanic action in the Camperdown district. Moreover, the complete absence of hot springs, fumaroles, or vapour vents, such as generally survive, in volcanic districts for long periods after the volcanoes themselves have become extinct, is further evidence that the volcanoes have not been in action for a long period of time; it also indicates that the volcanic forces are quite extinct, and are not likely again to burst into eruption.

Chapter IX.—THE WEATHER OF VICTORIA AND ITS CAUSES.

Weather is one of the most important factors in both physical and political geography. The weather controls the development of the physical features of a country, and determines its value for settlement by

man. Thus a country, in which the weather is hot and the rainfall small, will have a sparse vegetation, and no permanent rivers or lakes; and it will have dry river beds and lake basins, which are occupied by water only for a short time after rain. The surface of the country will, moreover, be gentle, as the contours will be determined mainly by the wind. Such a country will be of the desert type, and of comparatively little direct use to man. A country, on the other hand, in which the heat is moderate and the rains heavy, will support abundant vegetation, growing in thick forests and grass-covered steppes; it will have permanent rivers, which flow through deep valleys, and which, in time, will drain all the lakes; the form of its surface will be determined mainly by the action of running water and rain, and perhaps also of frost, and the resulting forms will be more varied and irregular than in the arid desert land.

The study of the weather in Victoria is of especial interest to geographical students, because it alone would teach us that Victoria is part of a great continent. Any resident in Melbourne, who understands the elements of **meteorology**,—the science which deals with the weather—could tell that he was living on the edge of one of the great land masses of the globe.

Weather is the general term used for those changes of rain and fine, heat and cold, wind and calm, sunshine and cloud, which depend on changes in the atmosphere. The term **climate**, on the other hand, has reference to the general average range of the weather. It deals with the annual rainfall, the annual range of temperature, the total amount of heat

annually received from the sun. These averages are obtained by regular observations of the weather for as many years as possible.

The weather of Victoria is governed by two main factors. The first is the distance of Victoria from the equator. It is situated more than one third of the distance from the equator to the South Pole, and lies in the temperate zone. These zones were so called by Parmenides, because they suffer neither the extreme heat of the tropical region—the torrid zone—nor the extreme cold of the regions round the poles—the frigid zones.

The second factor which governs the weather of Victoria is the passage across Australia from west to east, of a succession of great atmospheric disturbances.

As changes in the weather result from atmospheric changes, in order to understand them, we must consider a few leading facts in regard to the atmosphere.

The atmosphere is the layer of air which completely surrounds the whole of the earth. The air is a mixture of four gases, nitrogen, oxygen, argon, and carbonic dioxide, in the proportions of about

$$O = 20{\cdot}93\%$$
$$N = 78{\cdot}10\%$$
$$\text{Argon} = {\cdot}94\%$$
$$CO_2 = {\cdot}03\%$$

In addition, there are some rarer gases of no meteorological importance, and some aqueous vapour, the amount of which varies greatly. The aqueous vapour is derived by evaporation from the sea, from lakes and rivers, and from the surface of the land. The weight of the whole mass of air in the atmosphere presses

down upon the the earth's surface, with a pressure of $14\frac{3}{4}$ pounds to the square inch, or about 19 cwt. to every square foot.

As the air itself is very elastic, the weight of the upper layers of air compresses the air in the lower layers. Hence the air on the earth's surface is denser and heavier than it is at a higher level, and, ascending from the earth's surface, the air continuously diminishes in density. At the sea-level the air weighs $\frac{1}{13}$ of a pound per cubic foot. At the height of three miles above the earth's surface a cubic foot of air weighs only about half that amount. Practically the whole of the air occurs below the height of 40 miles. Above that level the air is so rarified that it no longer has any action on light, as has been proved by observations on the twilight; but some rarefied air extends to the height of 200 miles above the earth's surface, as is known from observations on shooting stars or meteors.

The principal changes in the atmosphere are due to heat. This heat is practically all derived from the sun. A little rises from the hot interior of the earth, but Haughton calculated that the earth receives 2208 times less heat from this source than from the sun. Still less is obtained from the moon, which reflects to the earth an amount of heat, that has been estimated as equal to the heat received from an ordinary candle, at the distance of a quarter of a mile.

The amount of heat received at any place on the earth depends upon the distance of the place from the equator, and on its height above sea-level. As the sun shines down vertically upon the tropical regions beside the equator, they receive more heat than the

temperate or polar regions, upon which the sun shines obliquely. Moreover, the atmosphere absorbs some of the heat passing through it; therefore, as the sun's rays have to pass through more air before reaching the ground in temperate or polar regions than at the

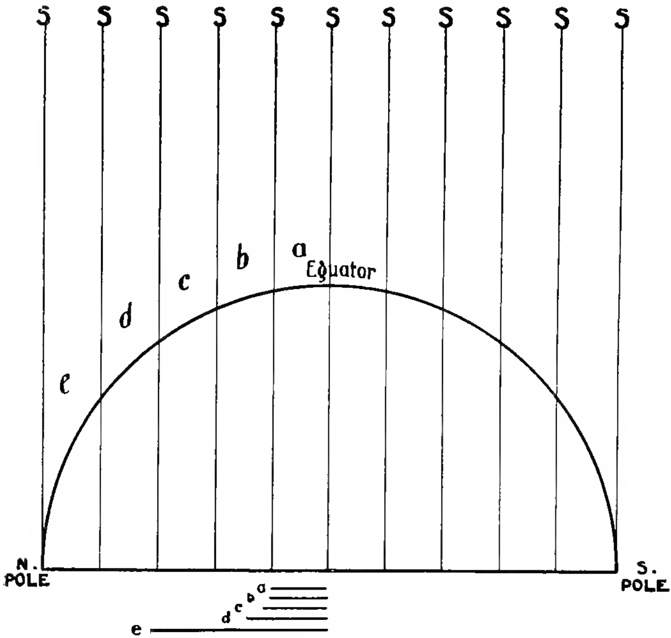


Fig. 95.—Diagram showing the different amounts of heat received from the sun in the different latitudes.

S, parallel rays of the sun; the rays being equal distances apart, represent eqnal amounts of heat received from the sun. The lines *a e* show the unequal lengths of the earth's surface.

equator, still less of it reaches the ground. Hence, as we go north or south from the equator, the amount of heat received from the sun becomes gradually less. Thus, if the mean temperature at the equator be 79·7

degrees,* at 20 degrees of latitude from the equator it will be 75·8 degrees of temperature; at 40 degrees of latitude from the equator it will be 56 degrees of temperature; at 60 degrees of latitude from the equator it will be 31 degrees of temperature; at 80 degrees of latitude from the equator it will be 6 degrees of temperature. Going from the tropics, 23½ degrees (or more correctly 23 degrees 27 minutes 44 seconds), away from the equator, there is an average fall of about 1 degree F. for every degree of latitude.

The lines of equal temperature do not, however, follow along the parallels of latitude. Owing to the unequal distribution of land and water, the lines, passing through places of equal temperature, have a somewhat irregular course. Lines, passing through places at which the temperature is equal, are called **isotherms.** For example, a line joining all places having a mean annual temperature of 50 degrees is known as the **mean isotherm** for 50 degrees. The isotherms are not only irregular in their course, but those for any given temperature do not occur at the same distance from the equator in the two hemispheres. Thus the mean temperature for latitude 30 degrees in the northern hemisphere is 70 degrees, whereas, for the same latitude in the southern hemisphere, the average temperature is only 67 degrees. A map of the mean annual temperature of the globe shows that in tropical regions the highest temperatures are on the land areas, and that most of the sea along the equator has a temperature of about 80 degrees. It further shows the remarkable

*Degrees are given according to the Fahrenheit thermometer, which is the more convenient for use in meteorology.

northward deflection of the isotherms in the North Atlantic, due, in part, to the influence of the Gulf Stream, but mainly to the influence of the warm south-westerly winds, which blow from the Atlantic against the western shores of Europe. The isothermal lines cross Australia along different paths in January and July, owing to the different action of land and water on the heat received from the sun.

The second geographical factor which determines the amount of heat that a place receives, is its height above sea-level. The sun's rays have to pass through less air to reach a mountain summit than to reach the sea-level. Moreover, it is the moisture in the air that absorbs the sun's rays, and the moisture is nearly all in the lower layers of the atmosphere. Therefore, as we rise above the earth's surface, the heat of the sun becomes more intense on any body that is directly exposed to its rays. Thus, a black bulb thermometer exposed in Thibet, at the height of 11,000 feet, has registered as high as 214 degrees F., a temperature higher than that of boiling water. Nevertheless, it is well known that weather is colder on the summits of mountains than in low-lying country. Mountains in many parts of the world are always covered with snow, which can often be seen from Melbourne, lying on Mount Macedon or Mount Dandenong, although none has fallen on the adjacent plains. The coldness of high elevations is due to the fact, that the atmosphere acts as a cloak, which keeps the earth warm; for it allows the heat from the sun to pass downward to the earth with a comparatively slight loss; but it lets through much less of the heat reflected from the ground. Accordingly the earth receives from the sun,

during the day, a great deal more heat than it loses by radiation during the night.

The amount of radiation from any place, depends on the amount of aqueous vapour in the atmosphere above it. We know that a cloudy night is warmer than a cloudless night; this fact is due to the clouds checking the radiation, and thus keeping the ground below warm. The clouds act thus as they are composed of aqueous vapour.

Most of the aqueous vapour occurs in the lower layers of the atmosphere; indeed, half of it is below the level of 6000 feet. Hence, mountains have less moisture above them than there is over the adjacent lowlands; and the heat which is received from the sun is more readily returned to space by radiation.

Accordingly, the temperature becomes steadily lower as we rise from sea-level. If the air were absolutely dry, then there would be a fall of 1 degree F. for every 180 feet of ascent; but owing to the presence of the moisture in the atmosphere the rate is much slower, and on an average it is 1 degree F. for every 300 feet of ascent.

The Pressure of the Atmosphere.

The air presses down on the earth with a pressure of $14\frac{3}{4}$ pounds on the square inch. This amount, however, is only the average; for the pressure varies with locality, and even at any one point on the earth's surface it is continually changing. The changes are due to local variations in the height of the atmosphere, and in the amount of aqueous vapour present in the air. Aqueous vapour is not quite $\frac{2}{3}$ as heavy as air,

and therefore the more vapour the air contains, the less heavily it presses on the ground beneath.

The chief changes in the weight of the atmosphere are those due to variation in its height. The surface of the atmosphere is disturbed by waves like those on the surface of the sea. The air is raised in wave-like

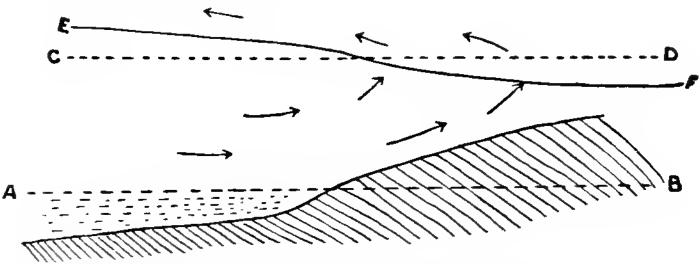


Fig. 96.—Sea Breeze:—*A B*, line at which the average pressure is 30 inches; *C D*, line at which the pressnre would be 25 inches but for the disturbing effect of the land; *E F*, line at which the pressure is 28 inches during the day.

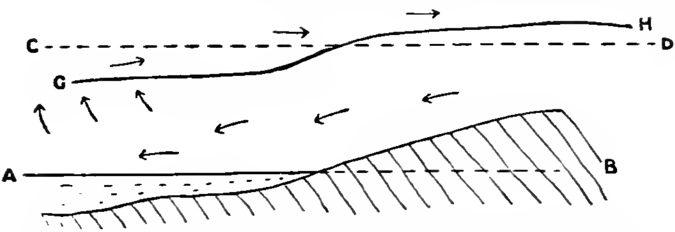


Fig. 97.—Land Breeze:—*G H*, line at which pressure is 25 inches at night *A B*, line at which the average pressure is 30 inches; *C D*, line at which the pressure wonld be 28 inches bnt for the disturbing effect of the land.

ridges or mounds, and lowered in troughs or pits. When the crest of an air wave is passing over a place, then the pressure of the atmosphere is heavier than when a depression is crossing it.

These variations in the pressure of the atmosphere are measured by the barometer, just as variations in

its temperature are measured by the thermometer. The distribution of pressure is most conveniently shown by maps, on which places, where the atmospheric pressures at the same time are equal, are joined by lines. Such lines are called **isobars**, or lines of equal pressure. These isobars surround areas of high pressure, like contour lines around a hill; while they surround areas of low pressure, like horizontal lines in a basin, or like the successive tide lines on the shore of a bay.

The variations in the atmospheric pressure depend upon heat. The surface of the ground not only loses its heat by radiation, but by slowly warming the air, which is immediately in contact with it. The air, being warmed, expands. If the ground in a particular district has become heated more than the surrounding areas, it warms the air resting upon it; and the expansion of this air causes an increase in length of the whole column of air above that district. Hence the upper layers of the atmosphere are pushed upward, and form a mound above the level of the surrounding air. The air thus upraised will flow outward in all directions, over the surrounding air, just as water flows outward when it escapes from the top of a vertical pipe. Accordingly, the amount of air left above the heated ground will be less than that over the surrounding colder districts, for they will have received some of the air from the hotter locality. The atmospheric pressure on the hot locality will be reduced, and the mercury in the barometer, therefore, will stand at a lower level than in the adjacent areas. The former will be a **low pressure area**, surrounded by higher pressure. If the pressure in the centre of the

low pressure area be 29·8 inches, there will be a line or isobar all around it, along which the pressure may be 30·0 inches, and further out another isobar, along which the pressure may be 30·02 inches.

A second cause that affects the atmospheric pressure in any locality is an upward movement in the air. As air becomes heated by the ground it expands, and thus becomes lighter; it therefore rises, and some of the colder and heavier air rushes in from the cooler districts, to take the place of the air in the warm ascending current. The rising air must flow outward from the top of the ascending column as a high level wind, and the inrush of cold air forms a low level wind. Thus the heat of the ground causes air currents or winds.

The action of the sun's heat has very different effects on land and on water. Water has a much greater **specific heat** than land; that is to say, it takes a great deal more heat to raise the temperature of a pound of water one degree than it does to raise the temperature of a pound of earth by the same amount. In comparing the specific heat of different bodies, water is taken as the standard, and given the numerical value of 1. The specific heat of dry ground is ·2, or one-fifth the specific heat of water. Accordingly, the amount of heat which will raise the surface of the sea one degree in temperature would raise that of any equal weight of the land beside it 5 degrees.

Conversely, water has a less radiating power than land. Water not only becomes heated much more slowly than land, but it gives up its heat much more slowly. In consequence of these properties, air currents are set up, wherever land and water occur

near together. During the day the land becomes much more heated than the sea; it warms the air immediately above it; the air rises; the cold air from the sea flows in as a low level current to take its place; and the hot air flows outward as a high level current. Thus during the day a cool **sea breeze** blows in upon the land. At night the breeze is in the opposite direction. Owing to the rapidity with which

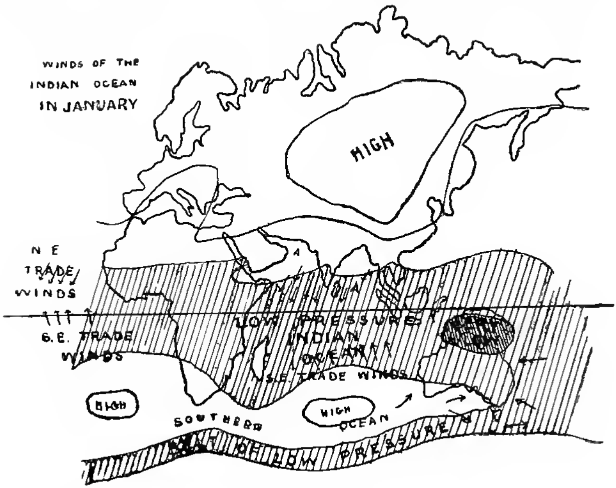


Fig. 98.

the ground gives up its heat by radiation, it is soon chilled, and the sea is warmer than the land. Accordingly, an ascending current now rises from the sea; it flows as a high level current over the land; while the cool air on the land flows out to sea to take the place of the ascending current. Therefore at night there is a **land breeze** blowing out to sea.

This alternation of land and sea breeze—or **monsoonal** changes, as they are termed—takes place every day on many islands and coasts. It can be

recognised on some parts of the Victorian coast, as in eastern Gippsland ; but in most parts of Australia the monsoonal winds are obscured by the variable winds.

Daily monsoonal changes are experienced on some small islands and on parts of the coasts of larger lands. In East Africa, however, there is a similar monsoonal alternation in the winds, but the change takes place

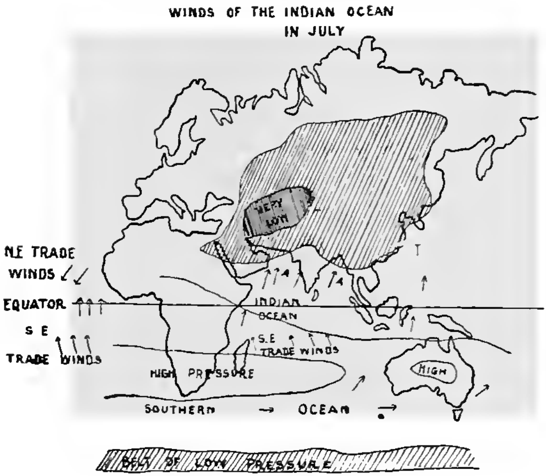


Fig. 99.

with the change of season, twice a year, and not every day. In January, the middle of the northern winter, the air over Asia is very cold and dry ; therefore the barometer is higher than it is further south, over the Indian Ocean. Accordingly, there is an air current from the area of high pressure in Asia, south-westward over the Indian Ocean. This wind is known as the **north-easterly monsoon**, for

winds are always named after the direction from which they blow.

On the other hand, in July, the northern summer, Asia is much warmer than the Indian Ocean. Accordingly the air pressure is lower than it is over the Indian Ocean. Therefore the wind blows from the Indian Ocean, north-eastward across India and the Arabian Sea, into Asia. This is known as the

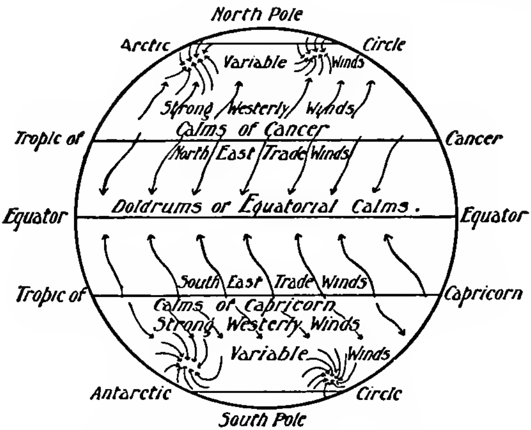


Fig. 100.—Prevalent Winds of the World.

south-westerly monsoon. These two winds blow regularly for months.

The **Trade Winds** are even more regular than the monsoons. Their name was given to them from the old use of the word trade, meaning steady. The trade winds are caused by the air over the equator becoming heated, and rising as a warm current. At a considerable height above the earth's surface this ascending current divides into two ; one part flows northward, as a high level current, into the northern

hemisphere; the other flows southward, as a high level wind, into the southern hemisphere. These winds keep at their high level until they are about 30 degrees from the equator, when, having been chilled, they descend to the earth's surface. The ascent of this hot air at the equator causes the colder air from the temperate regions to blow inward from north and south. If the earth were standing still, then these winds would blow due north and due south; but, as the earth is rotating on its axis from west to east, the winds are deflected westward. The reason for this deflection is that a particle on the

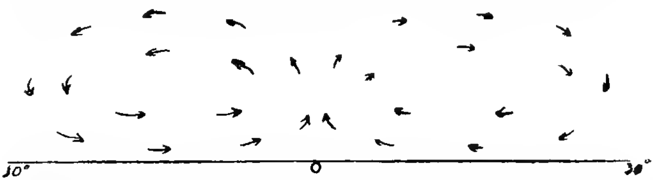


Fig. 101.—Diagram of the circulation of the atmosphere in the Tropics. Arrows show the ascent of the air above the equator *O*, and its descent at 30 deg. N. and S.

surface of the earth at the equator has a much greater velocity from west to east than a particle at latitude 30 degrees, because the equator is a larger circle than that of the latitude of 30 degrees. A point on the equator is travelling eastward at the rate of 1040 miles an hour. A point on latitude 30 degrees is moving only 900 miles an hour. Accordingly, if a particle of air in latitude 30 degrees in the southern hemisphere started northward toward the equator, and reached there in an hour's time, it would not strike the equator exactly opposite its starting point, but 140 miles further to the west; for, as the particle of air goes northward, it moves over a surface that is

travelling eastward, more and more rapidly than itself. Thus it would lag behind the earth, and its resultant course would be from south-east to north-west, instead of from south to north. Accordingly, a wind starting from the latitude of 30 degrees, and flowing straight towards the equator, moves towards the north-west in the southern hemisphere, and towards the south-west in the northern hemisphere. Thus, in the northern hemisphere, there is a steady north-easterly trade wind over the ocean; and, in the southern hemisphere, there is a south-easterly trade wind.

We have said that these winds blow towards the equator; that statement is only generally correct. They really blow to what is known as the **thermal equator,** that is the line round the earth, whereat the temperature is highest. This thermal equator does not coincide with the ordinary equator, owing to the unequal distribution of land and water. Moreover, the thermal equator varies in its position in different seasons of the year, following the sun north and south, as it goes from the equator to the tropics. The trade winds are separated along the equator by a belt of calms, known as the **doldrums**; they are a little south of the equator in January, and a little north of it in July. Two other belts of calms occur along the tropics, and are known respectively as the Calms of Cancer in the northern hemisphere, and the Calms of Capricorn in the southern hemisphere. In the zone between the latitudes of 40 degrees and 50 degrees, winds blow mostly from the west. To the north of latitude 50 degrees north, and to the south of latitude 50 degrees south, occur belts of variable winds, due to

great spiral winds travelling across the temperate regions from west to east. These variable winds are caused by winds blowing in spirals around areas of high pressures, which are known as **anticyclones**; and around areas of low pressures, which are known as **cyclones**. The winds blow spirally inward in cyclones, and spirally outward in anticyclones. The difference between these two types of atmospheric

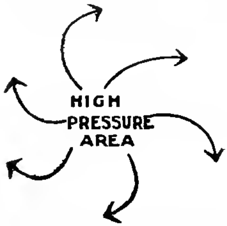


Fig. 102.—Direction of movement of the air in an anticyclone in the Northern Hemisphere.

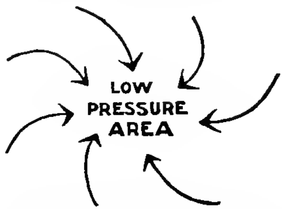


Fig. 103.—Direction of the movement of the air in a cyclone in the Southern Hemisphere.

disturbances must be clearly understood; they are stated in the following table:—

	CYCLONE.	ANTICYCLONE.
Winds	powerful and rapid, travelling up to 80 miles an hour.	gentle and slow
Sky	cloudy	clear
Weather	wet	dry

Cyclones are of enormous size, they are often 1000 miles in diameter; they may travel 1000 miles or more a day; they may last for two or three weeks, and in that time journey for 15,000 or 20,000 miles.

The spiral course of the wind around these cyclones and anticyclones is explained as follows:—Atmospheric depressions, or areas of low pressure in temperate regions nearly all move from west to east. Air naturally flows inward from all directions, to fill up any depression. We have seen, in the case of the trade winds (p. 212), that air currents moving northward, in the southern hemisphere, and going southward in the northern hemisphere, are both deflected to the west. Winds going in the opposite

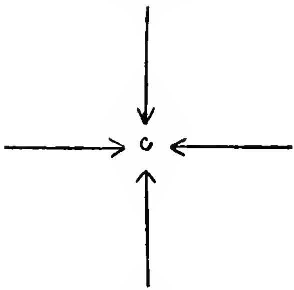


Fig. 104.

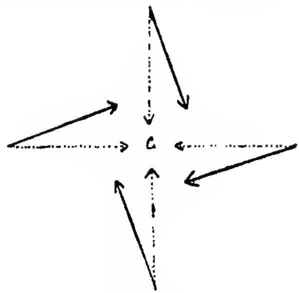


Fig. 105.

directions are deflected to the east. So these winds are always bent to the right in the northern hemisphere, and to the left in the southern. Foucault has proved that winds going eastward and westward have the same tendency to be deflected to the left in the southern hemisphere, and to the right in the northern.

Accordingly the air flowing in to fill up the depression of a cyclone, instead of blowing straight inward as in Fig. 104, will have a spiral course, as in Fig. 105, owing to its being deflected. The winds around the cyclone in the southern hemisphere will blow in the direction of the hands of a clock as they

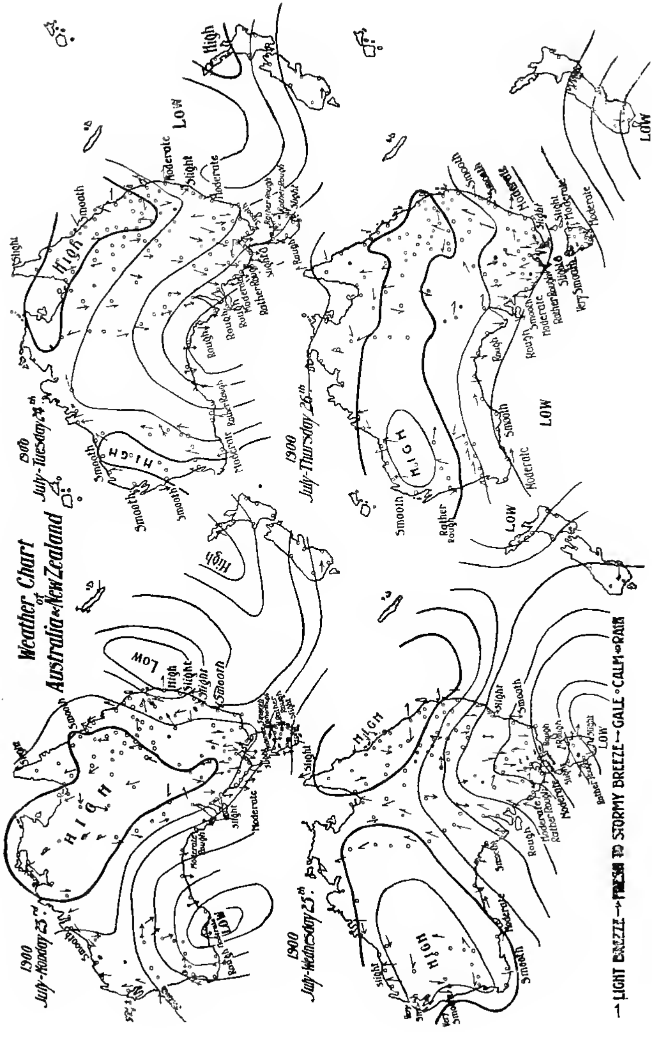
are deflected to the left; whereas, in the northern hemisphere, the winds will blow in the opposite direction to that of the hands of a clock, as they are deflected to the right.

As these "Variable" winds blow according to rule, it is easy to infer from the direction of the wind, the position of the centre of a cyclone. The rule is known as Buys-Ballot's Law. It states that if, in the southern hemisphere you stand with your face to the wind, the barometer will be lower on your left hand than on your right. If we look again at Fig. 105, we see that on whatever side of the cyclone we may be, so long as we keep our face to the wind, the centre of the cyclone (*c*) is always on the left-hand side. In the northern hemisphere the condition is reversed, and to have the barometer lower on your left, you must stand in the more comfortable position of having your back to the wind.

The Weather of Victoria.

After the foregoing account of some of the elementary principles of meteorology, we may proceed to consider the character of the Victorian climate. Australia occurs in the zone of the westerly variable winds of the southern hemisphere. It is crossed from west to east by a succession of cyclones and anticyclones, by which the condition of the weather is determined. We have seen that in anticyclones the winds are light, the sky is clear, there is no rain, and the weather is dry. That set of conditions is generally described as fine weather.

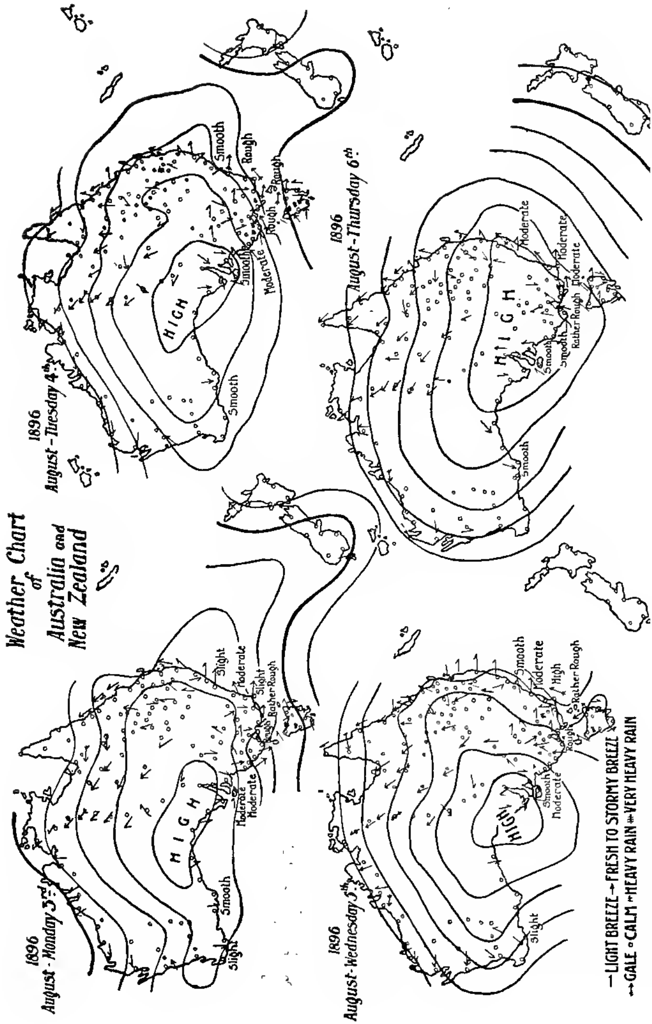
On the other hand cyclones are accompanied by cloudy skies, strong stormy winds, and rain—generally described as bad weather.


Weather Chart of Australia & New Zealand
1900 July-Monday 23rd
1900 July-Tuesday 24th
1900 July-Wednesday 25th
1900 July-Thursday 26th
HIGH
LOW
LIGHT BREEZE — FRESH TO STORMY BREEZE — GALE · CALM · RAIN

Parts of Australia which are covered by a high pressure area have calm, fine weather. Parts of the continent covered by a low pressure area, are subject to storms. The exact character of the weather depends upon the conditions and the shape of the low pressure areas.

A low pressure area is a vortex, into which the air rushes from all sides. If an Australian cyclone, or low pressure area, be so placed that it sucks in air from the tropical zone to the north, then Australia enjoys mild or warm weather, and hot north winds may come as far south as Melbourne. Under other conditions, such a cyclone may bring the moist air of the tropics into central Australia, and produce the fertilizing monsoonal rains. If, on the other hand, the low pressure area be so placed, that it sucks in air from the cold southern ocean, then it produces cold, wet weather.

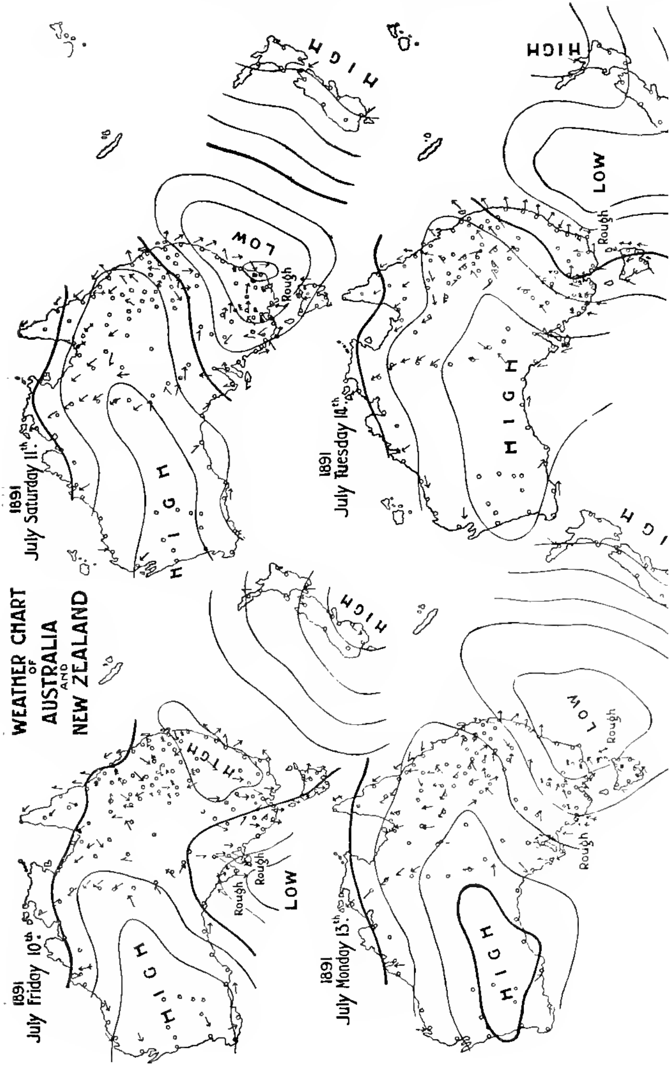
We have seen that the thermal equator moves southward with the sun, so that in January it is much further south than it is in July. The trade winds go southward with the thermal equator, and the belt of variable winds is also moved further south. Hence the path of the cyclones across Australia is further south in summer than in winter. Accordingly, we get more air from the tropics brought into Australia in summer than in the winter. Moreover, in summer, as the land areas get heated, they become areas of low pressure, and the low level winds blow from sea to land. Conversely, in winter, the land areas are covered by high pressure, and the low level winds blow outward from the land to the sea. Accordingly, in July, the average pressure in central Australia is


Weather Chart of Australia and New Zealand
1896 August - Monday 3rd
1896 August - Tuesday 4th
1896 August - Wednesday 5th
1896 August - Thursday 6th
HIGH
Smooth
Slight
Moderate
Rough
Rather Rough
High
— LIGHT BREEZE → FRESH TO STORMY BREEZE
↠ GALE ○ CALM ⇸ HEAVY RAIN ⇻ VERY HEAVY RAIN

high; it may one day in that month be 30·1 inches in the centre, while the rest of the continent is covered with pressures falling from 30·1 inches to 29·9 inches. In January, northern Australia is covered, on an average, with a low pressure area of 29·7 inches. This area covers northern Queensland, the northern territory of South Australia, and the Gulf of Carpentaria. To the south of this area, the pressure gradually increases, till the pressure of 29·9 inches occurs along the southern coast. Further south, over the Southern Ocean, the pressure falls again to below 29·7 inches.

The best method of studying the Australian weather is by the study of charts, showing the different stages in the passage of a series of cyclones and anticyclones across Australia. For the following examples of the charts I am indebted to Mr Baracchi.

The anticyclone which crossed Australia from the 23rd to the 26th of July, 1900, is a good illustration of our winter weather. On the 23rd July, all central and southern Australia was covered by a cyclone or low pressure area, and an anticyclone or high pressure area covered Queensland and the northern territories. By the next day this anticyclone had moved further eastward, while a second anticyclone coming from the west had just reached the western coast. On the 25th July, the first anticyclone had passed eastward, and lay over the York Peninsula of Queensland; while the second anticyclone had passed north-eastward, and covered the north-western part of Western Australia. The cyclone then lay all over south-eastern Australia, including Victoria. Under those conditions, there was no opportunity for tropical influences to reach southern


WEATHER CHART OF AUSTRALIA AND NEW ZEALAND
1891 July Friday 10th.
1891 July Saturday 11th.
1891 July Monday 13th.
1891 July Tuesday 14th.
HIGH
LOW
Rough

Australia, which was widely open to the cold, wet weather from the south. Southern Australia was thus under the influence of an "antarctic" depression, and experienced bad weather. On the 26th July, the first of the anticyclones had left Australia altogether, while the second had drawn itself out into a long band of high pressure, extending across northern Australia; and southern Australia was still experiencing the discomforts of the antarctic depression.

The conditions producing fine weather in winter are illustrated by the passage of the anticyclone, which crossed Australia between the 3rd and 6th August, 1896. This anticyclone passed on a track much further to the south than those represented in the first series of charts. The anticyclone in its passage moved along the line of the southern coast of Australia. Northern Australia was occupied by a cyclone, which was drawing southward the warm moist air from the tropics; while the antarctic weather was kept far away, out on the Southern Ocean, and thus southern Australia enjoyed fine, sunny, warm weather.

These two cyclones travelled across the continent at a fairly uniform rate; but sometimes the disturbances are delayed in their passage. Such an occurrence produced the great floods of July, 1891. On the 10th July one anticyclone lay over the coast of New South Wales, and a second covered most of Western Australia, and extended westward over the Indian Ocean. These two anticyclones were travelling in the ordinary anticyclone track, where high pressure most often occurs. Between these two anticyclones, a cyclone, shaped like an inverted V, ran up from the Southern Ocean. On

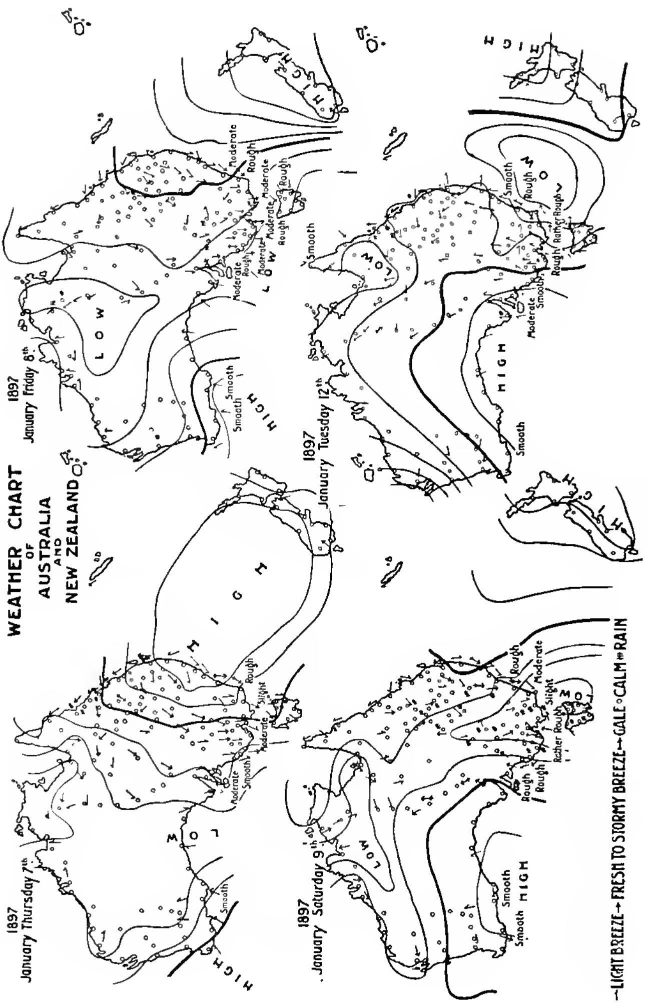

WEATHER CHART
OF
AUSTRALIA
AND
NEW ZEALAND
1897
January Thursday 7th
1897
January Friday 8th
1897
January Saturday 9th
1897
January Tuesday 12th
HIGH
LOW
Smooth
Moderate
Rough
Slight
Rather Rough
→LIGHT BREEZE→ FRESH TO STORMY BREEZE→ GALE ○CALM ⁂RAIN

Fig 109

the 10th July this V shaped cyclone extended up the Spencer Gulf and into the southern part of South Australia; it was accompanied by rain and cold. By the 11th July the cyclone had moved eastward, and lay over eastern Victoria, Tasmania, and part of the Tasman Sea, giving them cold, wet weather. Instead of this cyclone continuing its course eastward to New Zealand, it extended northward along the coast of New South Wales, and stopped there for two days. Thus on the 13th July Tasmania was still covered by the cyclone, and Victoria was still under its influence. The rains were prolonged, producing "the great floods." By the 14th, the cyclone had moved eastward into the Tasman Sea. Most of southern Australia was occupied by an anticyclone, but the eastern coast of Australia was still receiving the last showers from this cyclone.

The **summer weather** in Australia is determined by the fact that, on an average, the pressure is high over the Southern Ocean, while it is low in the interior of Australia. A good illustration of these atmospheric conditions is shown by the four charts for the 7th to the 12th January, 1897. On the first day, the south-eastern and south-western corners of Australia were touched by two anticyclones, the centres of which lay some distance south of Australia. The whole of central and northern Australia was covered by a cyclone, widely open to the north. On the next day, the second anticyclone had pushed its way along southern Australia to the Great Australian Bight. The third chart shows that the anticyclone had travelled still further to the east, while the whole of northern Australia was still covered by a cyclone.

The chart for the 12th January shows that the first of the two anticyclones had gone out to the Tasman Sea, while the second covered all southern Australia, as far east as western Victoria; and a great tropical cyclone extended over all northern and eastern Australia. This great cyclone could be most easily filled by air drawn in from the north, thus producing hot weather and monsoonal rains.

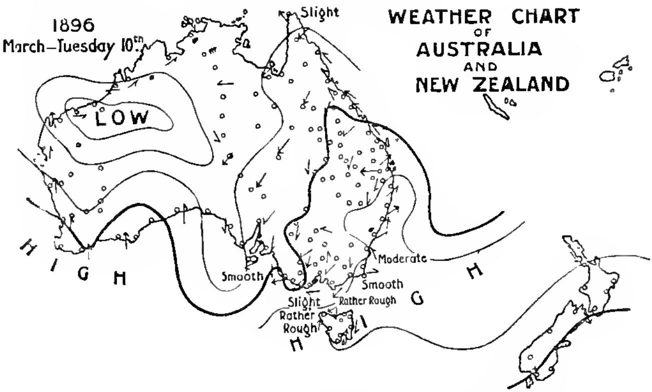


Fig. 110.—Illustrating the festoon type of anticyclone.

Heat waves, which sometimes reach Victoria, are also due to the passage of a cyclone between two anticyclones; but the cyclone is long and narrow, and extends from north to south, across Australia, between two anticyclones. The cyclone forms a sort of trough of low pressure, enabling the north wind to travel right across Australia to the southern coast.

The changeable weather of autumn and spring is produced by the passage of anticyclones, said to be of the **festoon** type, because, instead of their being bounded by isobars in long open curves, the isobars

are very sinuous, and form a series of festoons along the edge of the anticyclones. An illustration of a festooned type of anticyclone is given by the weather charts for March, 1896, and November, 1897. The wind blows in an eddy in each loop of the festoons, and thus the passage of the cyclone is marked by gusts and squalls, with frequent changes in the direction of the wind.

One of the most striking features in the weather of southern Victoria is the rapid change of the wind from north to south, which is often experienced early in the afternoon. The sudden change of the wind at Melbourne is not monsoonal in origin; for the land wind may be reversed to a sea wind at any hour of the day. Monsoonal changes do affect the weather of southern Australia, but they are masked by the passage of the atmospheric disturbances. The rapid change in wind from north to south is a cyclonic effect. The wind in front of an Australian cyclone blows from north to south, because the air is circulating in the direction of the hands of a clock; therefore, behind the centre of the cyclone, the wind is blowing from south to north. The cyclones often move at the rate of from 50 to 60 miles an hour. In a cyclone travelling at this pace, and with the last of the north wind only 30 miles from the beginning of the south wind, then the passage of this cyclone will be marked by a change from a north wind to a south wind, in half an hour.

We have so far considered the weather of Victoria as a whole, but the four quarters of the State have different climates. Mr. Baracchi has kindly prepared

the following account of the climates in the four divisions of Victoria:—

North-Western Quarter.

"This region escapes, to a great extent, the direct influence of both antarctic and tropical cyclonic systems, and is not subject to great and sudden variations of atmospheric pressure. Consequently weather changes are less frequent and less marked than they are in lower or higher latitudes of the adjoining areas. The prevailing winds are from between north-west and north-east in winter, and from between south-west and south-east in summer. All the winds are dry, or relatively dry; for, whichever be their direction, they can reach this region only after passing over a great extent of land, and precipitating most of their moisture on the way. The chances of rain are increased in those years in which the track of tropical cyclonic systems (monsoonal tongues, so called) descends further south than usual, and the track of antarctic cyclonic systems ascends further north than usual. A frequent type, in distribution of air pressure, is the overlapping of the southern edge of a monsoonal tongue, and the northern edge of a V-shaped antarctic depression, which gives rise to severe dust storms. This region is excessively hot in the summer months, the temperature of air in the shade rising sometimes as high as 120° F.; on the other hand, powerful radiation goes on at night, so that the diurnal range may be, in some cases, greater than 70° F. In the clear winter weather, the thermometer very frequently goes below freezing point. The north-western quarter is drier

than any other in the State, and is the hottest in summer. Its diurnal range of temperature is the highest, and it receives the largest amount of sunshine.

North-eastern Quarter.

This region does not escape the direct influence of antarctic and tropical cyclones to the same extent as the north-western areas; but the southern and eastern ranges offer considerable protection, and are instrumental in breaking up cyclonic systems, and in reducing and scattering their energy. Consequently the climate of this north-east quarter of the State is largely regulated by anticyclonic types of atmospheric pressure, especially over the plains between the ranges and the Murray, east of the Campaspe River. The average rainfall for the whole north-eastern quarter is, in round numbers, 32 inches, being considerably greater than that of the north-western quarter. But it must be remembered that this high average is influenced by the great rainfall over and in the vicinity of the ranges. An inspection of the complete table shows that, at different localities within the area under consideration, the annual average rainfall varies according to elevation and geographical position. Prevalence of north-easterly winds brings copious rains on this quarter of the State. In fact, nearly all its good rains are brought by north-easterly winds, which is a prominent feature of the climatic conditions of this region, where, as soon as the winds veer from north-easterly to north-westerly and westerly, and thence to south, the sky clears up and no further rain can be expected, until the winds turn to blow in due course from the north-easterly.

In the plains the weather in the winter months is mostly fine, with mild bright days, and cold, clear, frosty nights, with a diurnal range of temperature frequently as high as 40° F. In spring and autumn north-easterly winds prevail, bringing much rain, which is the most opportune and beneficial, at these times of the year, for all agricultural and pastoral interests.

The summer months are exceedingly dry and hot, temperatures frequently rising above 110°. Dust storms occur at this time of the year, and north-westerly winds are generally more frequent than at other times.

Of course the climate in the hilly country is quite different from that of the plains, both in regard to temperature and to moisture. Thus the temperature at Mt. St. Bernard falls as low as 17° in the winter months, and rarely rises higher than 94° in summer, and the annual rainfall is 67·06 inches; but, on the whole, the weather characteristics, arising directly from the distribution of atmospheric pressure, apply equally to the whole of the north-eastern slopes of the ranges which are influenced by the severe recurring cyclones, both tropical and antarctic.

The South-eastern Quarter.

The principal climatological characteristics of this region, which distinguish it from the climate of the areas north of the Divide, are as follows:—

(1) The relative smallness of diurnal, seasonal, and annual variation of its principal meteorological elements.

(2) The greater and more evenly distributed rainfall in the year.

(3) The relative freedom from abnormally severe extremes of drought and heat.

On the other hand, this region is subject to very frequent and often very sudden weather changes, which do not in the very least affect the northern areas. This arises from the circumstance that the weather in this south eastern region is almost entirely governed by antarctic cyclonic systems, whose influence does not go beyond the Divide. In all these respects the climate of the south-eastern regions is similar to that of the south-western districts, in so far as the normal annual values of the climatological elements are concerned; but it differs in respect of winds, rainfall distribution, and behaviour of cyclonic systems, which differences are in a great part accounted for by the topographical nature of the country.

The south-western districts are practically exposed to the winds from all quarters, and capture all the moisture contained in these winds ; but the hills and ranges of the south-east shelter large areas from the moist west and south-west winds. In the south-western districts the rainfall of the year is sensibly proportional to the prevalence of south-westerly winds, whereas the south-eastern quarter depends on the prevalence of south-easterly winds for an abundance of rainfall.

This explains the apparently curious fact that, in those years in which west and south-west winds largely prevail, the rainfall over the south-western

quarter of this State is above the average, while that over the south-eastern is below the average; and, in those years in which south-easterly winds prevail, the rainfall distribution is reversed.

Also, those areas in the south-east, which are sheltered from south-easterly winds, are considerably drier than those which are fully exposed to these winds; and this explains the apparently capricious and patchy character of the rainfall in Gippsland.

Antarctic cyclones, on reaching the eastern straits, frequently curve northward, and linger off the south-east coast, thus prolonging their influence over the extreme south-eastern districts, and causing very heavy and continued rains. The floods in Eastern Gippsland are generally due to this cause.

The South-western Quarter.

It has already been stated that as regards the normal values of the meteorological elements and their diurnal and seasonable variation, the climate of this quarter resembles that of the south-eastern areas. Some of the principal points in which the two climates differ have also been pointed out and the fact has been mentioned that both are mainly characterized by the influence of Antarctic Cyclonic Systems. It only remains to add that in the south-western region the passage of these cyclonic systems is practically unobstructed, and their influence on the climate is more direct. Thus weather changes are frequent and sudden; and they are often violent, especially in the more southern parts, but become less marked further inland. Rainfall is not only sufficiently copious, but is also evenly distributed throughout the year. There are no severe

extremes of heat and cold, nor long periods of drought, and, generally, the climate of this region is probably the most favourable and reliable in the state.

As a broad generalization of climate in this State, it may be remarked, *first*, that, in the southern half of Victoria, climate is very greatly influenced by antarctic cyclonic systems, and is therefore variable and irregular; but it is generally temperate, genial, and salubrious, with an ample rainfall well distributed throughout the year; and it is not usually subject to prolonged severities of temperature, extremes, and drought. *Secondly*, it may be remembered, that the northern half of the State is sheltered by the ranges from the moist, sea winds, and fully exposed to the heated winds from the interior of the continent, and is, to a very great extent, dependent for its rainfall on the indirect influence of tropical barometric depressions and electric conditions; it therefore possesses a dry climate, which is subject to great extremes of heat in summer, to powerful radiation, both solar and terrestrial, and to irregularly-recurring and irregularly-extended periods of drought. The northern climate, however, is temperate, and is preferable, in many respects, to that of the southern half of Victoria in the winter and for the most part of the spring and autumn; and it is such as to insure (as an estimated average) about one good year for agricultural and pastoral pursuits out of every four."

Rainfall.

The agricultural prosperity of Victoria mainly depends upon its **rainfall**. The water which falls from the sky as rain is mainly derived from the sea by

evaporation. It remains suspended in the air as invisible aqueous vapour, until it is condensed into the condition of visible **mist** or cloud. This condensation takes place when the air contains more moisture than it can retain. Air in that condition is said to be **super-saturated;** and the point at which the formation of mist takes place is called the **point of saturation.** The air may become saturated either by the discharge of more aqueous vapour into it, or by reduction in its temperature. Vapour is often turned into moisture by the chilling of the air when it comes into contact with the cold ground; this produces a low-lying mist or **fog.** When the condensation takes place higher in the atmosphere, it forms a **cloud.**

The four chief varieties of clouds [see Austral Geographies, Class VI., pp. 21-23] are the nimbus or rain cloud, the cumulus, the stratus, and the cirrus. The clouds of the last variety are shown by their optical properties to consist of minute crystals of ice.

As most of the water that falls as rain is derived from the sea, it is natural that coast lands should receive more rain than the interior of continents. Coast lands, which are mountainous, receive especially heavy rainfalls; for these high, cold masses of land rapidly chill the vapour in the atmosphere, till it is precipitated as rain. Thus the mountains of Gippsland receive a heavy rainfall, as they condense the moisture in the winds from the south-east. The highest average rainfall recorded from any one station in Victoria is Cape Otway, which receives 70·8 inches a year. The eastern coast of New South Wales receives a heavy rainfall, because its mountains condense the moisture carried by the warm winds from

the Pacific. Where, however, coast lands are low and warm, they may repel rainfall instead of attracting it. Thus the trade winds, blowing across the low plains of the Sahara, produce dry weather; but when they strike a mountain ridge, the little moisture carried inland is at once precipitated. The arid condition of Central Australia is due to the fact that most of the moisture, that the winds carry on to the continent, falls upon the coast country. Thus in Victoria, the rainfall north of the Victorian Highlands is much less than it is to the south (see Appendix III. No 1.); for the winds are dried before reaching the northern plains; and, moreover, the temperature of the air is increased by the heat reflected from the ground, so that the air absorbs moisture rather than precipitates it.

In Central Australia the irregularity of the rainfall is due to the fact, that it requires an unusual combination of circumstances. Rain occurs only when the wet winds of the tropical cyclones reach the interior of the continent, and when some change occurs in the temperature, which forces them to drop their moisture as rain. In the Lake Eyre country the whole sky is hung day after day in summer with dark grey clouds; but these are so high, and the ground beneath is so warm, that there is nothing to chill the clouds and cause them to fall as rain.

Various schemes have been proposed to secure, under such conditions, the artificial falling of the rain. Success has been achieved by firing explosive shells into the clouds; the shock of the explosion causes the condensation of the moisture, and its fall as rain. It has often been observed that the firing of heavy guns, when the air is charged with moisture,

produces a fall of rain. The powerful explosions in the blasting operations at Mount Lyell often cause a shower of rain; and they are followed, on wet days, by a sudden increase in the heaviness of the rain.

The artificial production of rain by concussion, requires, however, exceptional conditions. It can be successful only when the air is almost at the point of saturation, and the clouds are comparatively low. Similar experiments have been made to prevent the formation of hail storms, but these have not been attended with satisfactory results.

Victoria, as a whole, has a satisfactory rainfall, though its distribution is unequal. The average annual rainfall of the whole State, taken to the end of 1900, is 26·68 inches. The annual rainfall from 1887 to 1900 is given in the following table:—

ANNUAL RAINFALL IN VICTORIA.

Year.	Inches.	Year.	Inches.
1887 ...	... 32·85	1894 ...	... 29·61
1888 ...	... 20·28	1895 ...	... 20·93
1889 ...	... 33·57	1896 ...	... 22·75
1890 ...	... 29·90	1897 ...	... 22·29
1891 ...	... 26·32	1898 ...	... 21·22
1892 ...	... 25·99	1899 ...	... 24·34
1893 ...	... 30·39	1900 ...	... 25·22

The distribution of the rainfall of Victoria is shewn by the following table, kindly drawn up by Mr. Baracchi:—

Basin.	Rainfall in Inches.	
	Rainfall 1902.	Yearly average.
Glenelg and Wannon Rivers...	23·25	28·49
Fitzroy, Eumerella, and Merrie Rivers ...	25·68	31·03
Hopkins River and Mt. Emu Creek ...	19·61	26·65
Mount Elephant and Lake Korangamite ...	23·25	25·17
Otway Forest	32·18	40·52

Basin.	Rainfall in Inches. Rainfall 1902.	Yearly average.
Moorabool and Barwon Rivers	19·24	26·80
Werribee and Saltwater Rivers	24·22	27·26
Yarra River and Dandenong Creek	32·42	34·86
Koo-wee-rup Swamp	28·17	36·28
Sonth Gippsland	33·67	40·35
Latrobe and Thomson Rivers	33·23	38·45
Macallister and Avon Rivers	24·14	27·03
Mitchell River	32·23	30·88
Tambo and Nicholson Rivers	31·49	30·23
Snow River	35·62	37·08
Murray River	12·89	24·94
Mitta Mitta and Kiewa Rivers	21·49	36·27
Ovens River	21·2[illegible]	44·14
Gonlburn River	16·76	28·02
Campaspe River	16·19	26·72
Loddon River	11·57	20·39
Avon and Richardson Rivers	12·22	17·20
Avoca River	9·88	19·40
Eastern Wimmera	13·10	24·55
Western Wimmera	12·81	21·91
Mallee	8·71	16·01
Average for the State	—	26·68

The amount of water which falls on Victoria is enormous. The total received every year has varied from 28 cubic miles of water in 1888, to 46 cubic miles in 1887. The local distribution is, however, very irregular. It is highest in the valley of the Tarwin, in southern Gippsland, with an average of 47 inches. It is lowest in the Mallee, with an average of 17·03 inches. The average for the Wimmera is 22·19 inches, and for the Goulburn 28·07 inches. Special localities show a still greater range of variation. The highest record for any place in one year is 96 inches, which fell at Wood's Point in 1887. The lowest that has been recorded was at Yelta, on the Murray, where, in 1888, the rainfall was 4·46.

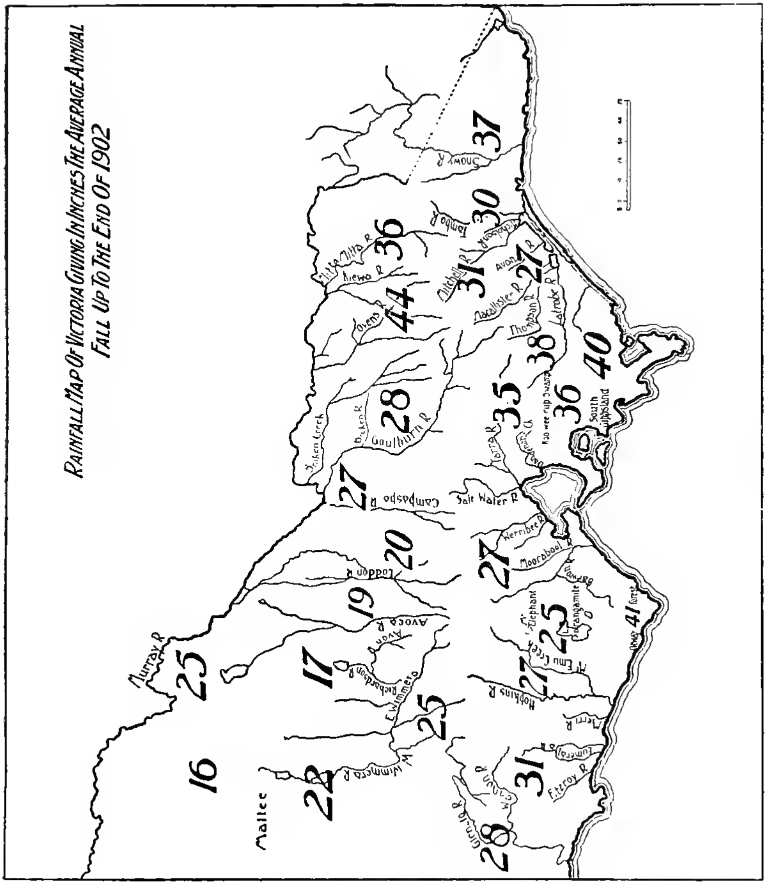

RAINFALL MAP OF VICTORIA GIVING IN INCHES THE AVERAGE ANNUAL FALL UP TO THE END OF 1902
Murray R
25
16
Mallee
22
W Wimmera R
17
Richardson R
E Wimmera
25
Avon R
Avoca R
19
Loddon R
20
Campaspe R
27
Goulburn R
28
Ovens R
44
Kiewa R
36
Mitta Mitta R
Tambo R
30
Snowy R
37
Mitchell R
31
Avon R
27
Macallister R
Thompson R
Latrobe R
38
40
South Gippsland
36
Yarra R
35
Salt Water R
Werribee R
Moorabool R
27
Barwon R
Corangamite
25
41
Hopkins R
27
Merri R
Eumeralla R
Fitzroy R
31
Glenelg R
28

Fig. 111.

The lowest recorded mean in Victoria is at Minafree, in the county of Karkarooc, which has a rainfall (based, however, on the average of only six years' observations) of 10·76 inches.

The distribution of rain in Victoria is marked on Fig. 111, where the average fall in inches is shown for the river basins and districts.

Snow falls but rarely in the lowlands of Victoria; but the high pene-plains and mountains, which form the Australian Alps in north-eastern Victoria, are covered deep in snow for three or four months in the year. From June to October the passes are closed by snow, and the cattle are driven from the higher plains to the valleys. The snow is so deep on the high plains, that they can be crossed only by the use of the long Norwegian snow-shoes, known as Ski (pronounced she). Some snow may last till Christmas in the gullies on the southern slopes of the mountains, and snow showers may occur at any time of the year. But there is no mountain in Victoria covered in perpetual snow.

Part III.—POLITICAL GEOGRAPHY.

Chapter I.—GEOGRAPHICAL EVOLUTION OF VICTORIA.

We have now seen the work of the principal geographical factors that prepared Victoria for settlement by man, and may briefly survey the chief stages in the progress, through which the State has passed.

At the first period of its known history (Lower Palæozoic) most of the State was covered by the sea; the highlands of Dundas, in the south-west, and of Benambra, in the north-east, most of the south coast, and a belt of country that ran northward from Geelong, past Lancefield Gap, through Mount William and Heathcote, and the line of the Colbinabbin Range may have been land throughout this period. Then followed a time during which thick beds of mud and sand were laid down on the old sea floor; and, in the next period, these beds were crumpled into folds by side pressure, as if they had been sheets of paper. The pressure was from east to west, so that the main folds ran from north to south. The arches of the folds formed ridges, separated by valleys along the troughs; and the ridges were slowly reduced by the various forces of denudation. Then followed the intrusion of two series of granitic masses forming two mountain chains, which ran east and west. The northern of the two remained for a long time the principal, as it was the "Primitive Mountain Chain" of Victoria. There were older mountains in Victoria, but they did not form the main line in the State.

The southern chain covered Bass Strait and the southern shore of Victoria. It may be named the Bunurong Mountains, after the tribe which lived along the coast of south-eastern Victoria.*

The movements, which formed these two mountain chains, were accompanied or followed by great volcanic disturbances; one line of volcanoes ran north and south across eastern Victoria, and piled up a ridge of volcanic rocks, along what is now the Snowy River.

*For the name of this tribe I am indebted to Mr. A. W. Howitt.

Rivers flowing down the flanks of the Primitive Mountain Chain cut out great river basins; some of them were flooded by the sea, or by great estuaries, and they were filled with coarse sandstones, which now form the Grampians, the Cathedral Range, and the mountains around Mount Wellington.

In the next stage great snowfields covered the summits of the Primitive Mountain Chain of Victoria; and from these snowfields glaciers crept down the valleys of Bacchus Marsh, Heathcote, the Loddon, and the Ovens, etc., and deposited great ridges of moraine, and broad sheets of glacial clays. Then followed a warmer period when the Great Central Valley of Victoria between the Primitive Mountain Chain and the Bunurong Range, was occupied by swamps and lakes, in which accumulated the Gippsland coal seams. In the next stage the Bunurong Range was completely destroyed, and an inland sea ran up the basin of the Murray; so that the Darling, the Murrumbidgee, and the Hume or Upper Murray, entered the sea as independent rivers (Fig. 57). At the same time the sea covered much of southern Victoria, forming the coast plain of eastern Gippsland, and covering most of the lowlands of south-western Victoria. The Ballarat plateau was then the southern shore line of Australia, while the Otway Ranges and the southern Gippsland Hills were a chain of islands off the coast. Denudation was meanwhile attacking the land, and cutting down the northern mountainous country into wide peneplains. They were then elevated into plateaus, which were re-attacked by the forces of denudation, and cut up into a maze of ridges and gullies. At the same time the sea receded from Victoria and Tasmania. The

material obtained by the denudation of mountains in northern Victoria, helped to fill up the Murray basin and form the wide Murray flats. Meanwhile the earth movements connected with the subsidence of Bass Strait, and leading ultimately to the separation of Tasmania from Victoria, had restarted volcanic action on a tremendous scale. The western part of the floor of the Great Valley was covered by a flood of basalt from numerous volcanic vents, while other outbreaks spread sheets of lava over the Divide, and poured long flows down the valleys to the north.

Modern Victoria consists, then, of four principal geographical divisions. First, the triangular mass of the highlands of eastern Victoria, and, in the west, the Ballarat plateau, and the highlands of Dundas; this element consists of Palaeozoic and still older rocks. Secondly, the broad Murray plains which occur on the northern flanks of the Palaeozoic backbone of the State, and are formed of rocks of recent age. Thirdly, the Great Valley of Victoria, the floor of which is covered in places by the sea, elsewhere by the alluvium of the estuary of the Gippsland rivers, and by the basalt sheets of south-western Victoria. Fourthly, the remnants of the old Bunurong Range, the Otway and the Gippsland Hills on the southern side of the Great Valley of Victoria.

Chapter II.—THE ABORIGINES.

Study of the Geography of Victoria would be incomplete, if it did not consider the influence of the geographical factors on the value of the country to

man. The first important political factor in the development of a country is the character of the men who occupy it. All through most of even its geological history, Australia has been isolated from the northern world. It has been biologically conservative, and its inhabitants have been of old-fashioned types,

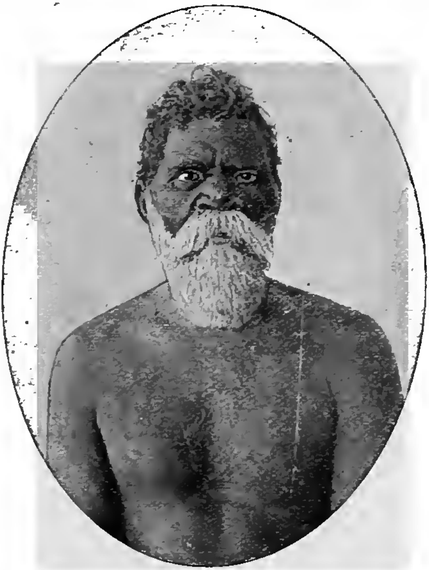


Fig. 112.—An Australian Aboriginal (Lake Eyre).

readily replaced, when newer races had a chance of entry. This fact is illustrated by the history of man in Australia. The first human settlers entered from the north. They were probably negroes, belonging to that section of the negro race known as the Papuans; but it is possible that the first immigrants were negritoes, a division of mankind including the pigmy races of south-eastern Asia and of Africa, and probably

also the South African bushmen. The negritoes may be either a section of the negro race, or an altogether distinct and older race. Until this question has been settled, and it is known whether the first inhabitants of Australia were negroes or negritoes, it is safer to speak of the main elements of our aboriginal population as either negro or negroid.

Fig. 113.—A Vedda.

The first immigrants reached northern Australia from Malaysia; they spread throughout the continent, and probably reached Tasmania before the severance of the land connection across Bass Strait. The occupation of Australia by this negro or negroid race, was disturbed by the arrival of people of a higher and more intellectual type. These second immigrants

were members of the same great race as ourselves. They were Caucasians; but they belonged to the section of that race in which the colour of the skin is black. They are known, using Huxley's term, as Melanochroi. These Melanochroi, or Black Caucasians, are now represented by the Vedda of Ceylon, the Dravidians of southern India, the hairy Ainu of Japan, and the frizzly-headed Somali, whose resemblance to the Australian aborigines has been recognized by many Australians on seeing the Somali boat boys at Aden. The Black Caucasians intermarried with the primitive negro or negroid inhabitants, and the Australian aborigines were the offspring from this mixed marriage. The Black Caucasians, in fact, did for the Australian aborigines, what the Saxons and the Normans did for the ancient Britons. The Caucasians not only gave the Australians their long, black hair, but they left their descendants a finer mind and a greater capacity for civilization than the pure African negro, or the negrito. The Tasmanians remained in their primitive condition, for they were isolated by Bass Strait, and did not receive the addition of Caucasian blood. Some tribes of the mainland may also have remained pure bred; the stories of Loowerr, the wild man of Wilson's Promontory, may, as suggested by J. Matthew, be based on the survival there of some of the more primitive race. But the people of the Tasmanian type were in time exterminated, and the mainland was peopled throughout by the higher mixed race.

If Australia had been as fertile a country as India or as parts of Equatorial Africa, it would probably have been peopled by a race strong in numbers and

character. But much of Australia is a severe fatherland. Vast areas are liable to drought, and other areas are almost impassable, except to an organized

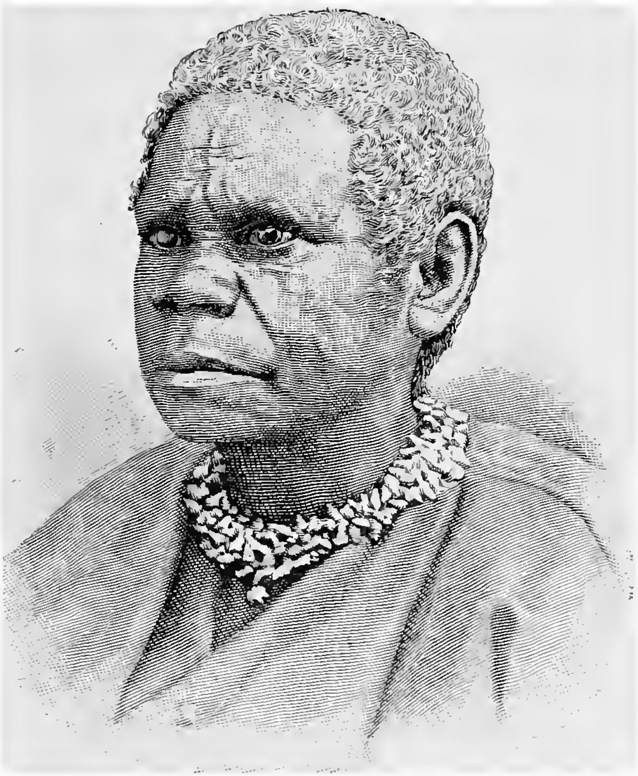


Fig. 114.—A Tasmanian Aboriginal.

caravan. Accordingly the Australians remained a scanty, scattered, nomadic people. All over the world the nomad is doomed as soon as he comes in contact with the settled conditions of modern civilization.

The Australian aborigines have suffered the same fate as the North American Indians and the Cape Bushmen. The destruction of the game on which they lived; the sudden change of tribal customs, and loss of old restraints; the introduction of alcoholic drinks and of infectious diseases, spread by the distribution of germ-laden old clothes; the liability to disease due to sudden change of habit or mode of work, all tended to reduce the numbers of the aborigines.* In southern and south-eastern Australia, at least, their fate was certain.

Chapter III.—THE COLONISTS.

The aborigines have gone, as their nomadic nature, which was forced on them by geographical necessities, was economically intolerable when the country was taken up for agricultural and pastoral purposes. Their disappearance has necessitated the development of Victoria on different lines from those followed in Africa. There the negro has increased in numbers where European rule has been established. There may be a temporary local decrease, when Europeans come in contact with nomads, such as the Bushmen, until these natives are replaced by tribes more amenable to discipline; or when incompatibility of social systems may lead to the withdrawal of

* The spread of the sleeping sickness, a fatal disease of the nervous system, now prevalent in Uganda, is an illustration of the liability of a native tribe to destructive epidemics, after a sudden change in their condition of life. Like the Australian aborigines, the people of Uganda are of mixed Black Caucasian and negro race.

population, as when some of the Arabs of British East Africa fled with their followers, and settled in German East Africa. But, so soon as the first shock of change is over, the negroes, under European control, increase apace. The inevitable development, in those countries, is black labour working under white control; white settlers are, therefore, mainly capitalists or planters, with others engaged in trade, as skilled labourers, and personal attendants. In Victoria, the disappearance of the aborigines rendered necessary the introduction of fresh labour. Artisans had to be imported, and, as they were indispensable for the success of the country, they had to be given favourable treatment and equal political powers. The labourers who came here were men of independent spirit, many of them smarting from the petty tyrannies of the European caste systems. Here they were not tied by that traditional subservience to an old nobility, which the spread of education in England has tended to increase by fostering the historic sentiment. In Victoria there was nothing to restrain the artisans from the full use of their political power. Any hesitation on the part of the British immigrant would have been overcome by the influence of the Continental Revolutionists, who flocked here, tempted by the gold discoveries of the early fifties, and driven from Europe by the failure of the "Young Europe" movement in the late forties. Hence, but for the geographical influences which made the Australian aborigines nomads, Australia, like Africa, might have developed into a country of aristocratic squatters, or wealthy capitalists, employing black labour; but the disappearance of the aborigines

and the sudden inrush of artisans at the time of the gold discoveries, has led to the development of Victoria as, perhaps, the most democratic community on earth.

A second consequence of the disappearance of the aborigines has been the re-peopling of Victoria by a mixed race. The old British provinces still retain many racial differences; but, in Australia, the East Anglian, with his intermixture of Danish and Dutch, has settled beside the West Saxon of Somerset; the Teutonic Yorkshireman has intermarried with the Welsh Celts; the children of Gaelic Scots and Lancastrians may have a dash of Phœnician blood by intermarriage with the Cornish. And, in Victoria, not only is there a mixture of the different British types, but of many foreign races as well. The rush to the goldfields brought French and Germans, Russians and Poles, Scandinavians and Italians. Mixed marriages generally result in a healthy, vigorous offspring. To the mixed parentage of the modern Australian is to be attributed much of his success as the maker of a new Fatherland.

A further result of the mixed origin of the Victorian people is the necessary absence of a State church. In Victoria, with its mixture of Catholic Irish, Presbyterian Scotch, and Anglican and Nonconformist English, no one form of Christian religion held overwhelming supremacy, and a State church was impossible. The granting of equal rights, and even State subsidies, to opposing creeds, not only to the three British forms of religion, but also to the Lutherans, Moravians, Jews, and Greek Church, has nourished a degree of religious toleration or indifference

which, to a newcomer, is one of the most striking features in the spirit of young Australia.

The physical intermixture has been accompanied by a release from old European traditions and prejudices, and thus tended to the free growth of the democratic spirit. The immigrants came to a country that was practically empty, and they all came nearly at the same time. The squatters, it is true, came before the gold diggers; but the difference in time was not great, and the later comers fiercely resented any attempt at dictation by their predecessors. The squatters felt none of the responsibility of the old European nobility, and the new-comers had none of the traditional respect of the European commercial and labouring classes for the lords of the soil. Under such conditions the squatters were not likely to accept the principle, which is the basis of the British poor-law, that the support of the people must be the first charge on the land. When great national works had to be made, there were no leaders, who felt bound, by the responsibility of birth, to undertake them. The democratic majority had no right to expect individual owners to risk their fortunes in schemes, in which they were not interested. Hence great public works, which in England were undertaken by private companies, as in the case of the railways and docks, or by wealthy nobles, such as the building of canals by the Duke of Bridgewater, and the drainage of the fens by the Russells, had, in Victoria, to be undertaken by the State. Hence, the socialistic movement, which had been so easily defeated in Europe, here gained a victory as complete and easy as the disappearance of the aborigines had made it inevitable.

Another result of our national youth and geographical isolation is that our country is free from the heavy burden of bad debts, incurred by wars, and from the cost of the armed peace of Europe. The victories in Australian history have been those of the engineer and the agriculturist. The heroes of Australia are not the men who have won fame at the cannon's mouth. They have had to fight a harder fight without the reward of even a bubble reputation. They are the unknown swagmen, who have tramped from Sydney to Fremantle to get an extra 2s. a day wages; or forgotten prospectors, who have discovered the mineral resources of the continent during feats of travel, which, if applied to arctic exploration, would long ago have carried them to the north pole. It is largely to our geographical conditions, that we owe the remarkable absence, from the Australian spirit, of militarism, in spite of holding Imperial patriotism with the fervour of a religion. Hence, Australia has had a chance of devoting its revenue to national works and education. The cost of the British army and navy for the year 1894-5 was £35,000,000* or 34·4 per cent. of the Imperial expenditure; the cost of education to the Imperial exchequer was £6,800,000 or 6·7 per cent.; including all the charges for museums, picture galleries, scientific research, etc., it was 9·6 per cent. In Victoria the cost for the same year, 1894-5, was £194,000, or 2·8 per cent. of the total expenditure, for defence, and 9·2 per cent. for education. Thus, taking the relative expenditure on defence and on education, Victoria is able to spend more than fifteen times a larger proportion of its income on education than is

*In 1903-4 it is to be £65,000,000.

paid out of the British Imperial revenue. In England, the national debt of £750,000,000 was practically all spent in war. In Victoria, of our State debt of £49,000,000, nearly £37,000,000 was spent on railway schemes, and over £8,000,000 on water supply and sewerage.

Chapter IV.—THE PASTORAL OCCUPATION.

Geographical factors have not only deeply influenced the Australian spirit, but have directly guided the movements of the population in Victoria. The forbidding barrenness of the coastal sand dunes saved Victoria from being founded as a convict settlement. The colony was first rendered successful by the richness of the grazing plains lying north and west from Melbourne; they were the direct result of eruptions of basaltic lavas, the decay of which produced a soil rich enough for a splendid turf, but too shallow to support forests.

The first period in the development of Victoria was that of the occupation of most of the State for sheep and cattle runs, between 1836 and 1846.

It was of course natural that the first pastoral settlements should have been made from Melbourne; but as soon as all the country easily reached from that town had been "taken up," Geelong became the centre of an independent line of settlement. In 1836 many emigrants, recognizing the advantage of Geelong as the port of entry for the western plains, settled at Point Henry, the projection which divides the inner from

the outer harbour of Geelong. These settlers took up the land along the Barwon Valley. In July 1836, the three brothers Manifold, and Steiglitz, and Roadknight landed at Point Henry, and pushed westward beyond the Barwon Valley; and J. C. Dark settled on the

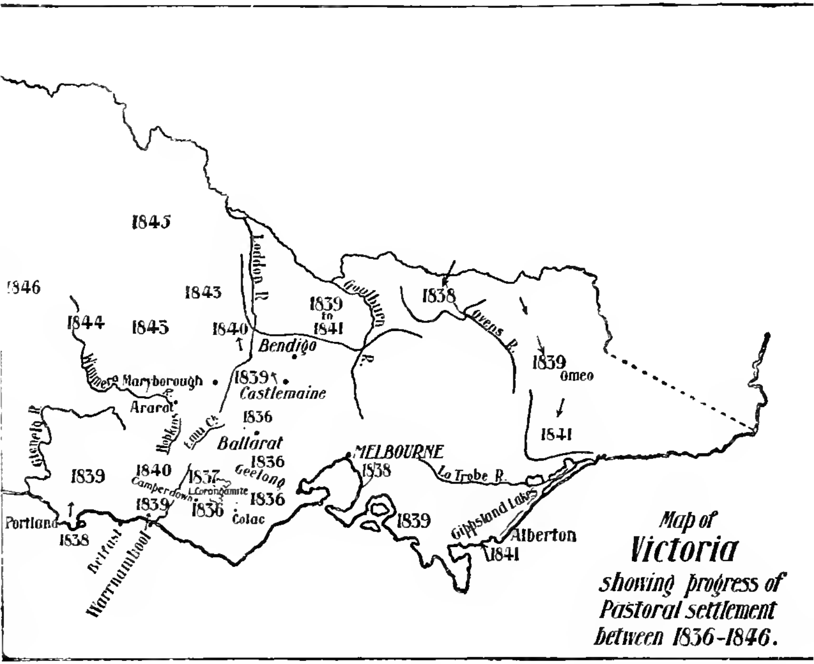


Fig. 115.

Barrabool Hills. In September 1836, the Clyde Company occupied the land on the Moorabool and Leigh Rivers, between Geelong and Mount Buninyong. The Derwent Company occupied the country from Queenscliff to Geelong, and other settlers occupied the Upper Moorabool. By the end of 1845, there were 60

stations in Bourke, and about the same number in the county of Grant, practically all the land in these two counties being taken up.

Meanwhile the country along the Murray was being occupied by emigrants from New South Wales. In 1838, all the land was taken up between the Ovens and the Goulburn.

From 1839-41, the settlers from New South Wales had extended their occupation of the country westward, from the Goulburn to the Loddon; and by 1845, there were 112 stations in the Murray district.

Eastern Gippsland also was first reached from north of the Murray. A bad drought in New South Wales, during 1838 and the following years, drove the squatters to seek fresh pastures.

McFarlane settled at Omeo in 1839, and his overseer, Angus MacMillan, crossed the Divide in May of the same year, and travelled across Gippsland as far south as the Latrobe River. He discovered the Victorian Lakes; but he failed in his effort to reach Corner Inlet, as the forest scrub proved impenetrable. In the year 1841, Strzelecki (pronounced Streleski) and MacArthur crossed from Omeo, and followed MacMillan's track to the Latrobe; they forced their way through the forests which had foiled MacMillan, and reached Western Port, and Melbourne.

Meanwhile the area of occupation had pushed out eastward from Melbourne towards Gippsland. Highett led the way in 1836, when he crossed Dandenong Creek. The township of Dandenong was founded in 1838. In the same year all the coast, from Cape Schanck and Point Nepean to Arthur's Seat, was taken

up by one squatter. By 1839, the country was occupied as far east as Western Port, the most advanced settlers being Anderson and Massie. Their station was close to the mouth of the Bass River, where they relieved Strzelecki, after his arduous journey from the Latrobe.

Alberton was founded in February 1841, and the same year McFarlane cut a road from Omeo to the lakes, and MacMillan settled on the Avon. He was followed, between 1842 and 1844, by others, who came *via* Omeo, and occupied the country around the Gippsland Lakes.

The Western District had, in the meanwhile, made even more rapid progress. By 1839, the western plains were occupied as far as Colac, Camperdown, and Buninyong. In that year Watson crossed the Hopkins River, and he was followed by men with names now so well known as those of Chirnside, Donald, Wyselaskie, and Black. Black and his partners settled on the lower part of Emu Creek, and James Dawson, well known from his championship of the aborigines, settled near Belfast. Portland had been founded in 1838, and the town proclaimed in May 1839. Occupation spread inland from it and from Warrnambool, especially up the valley of the Glenelg. In 1837, Winter settled at Tahara; the station of Koonongwootong was founded at Coleraine, and occupation thence reached the Wannon Valley. The settlers in this area were reinforced, in 1840, by men travelling overland from Geelong.

The Wimmera district was also reached from the south-western plains. In 1839, McLachlan occupied Mt. Cole, and Simpson founded four stations from

Clunes to Castlemaine. In 1840, three MacKinnons, Grice, and others followed the Loddon as far down as Inglewood; and, in 1843, Darlot, Simpson's manager, went north-west into the Wimmera. In 1844, settlement had reached Mount Arapiles, and, by 1846, it had extended as far west as the South Australian border.

About the same time, efforts were made to occupy the Mallee country. In 1845, three squatters reached the northern end of the Avoca and Lake Tyrrel. The Murray, in north-western Victoria, was first reached from the south, in 1847, by Beveridge, who was killed there. The Mallee country was, however, regarded as useless, and the early settlement of Victoria was practically completed when, in 1846, all the country had been taken up, on lease, to the edge of the Mallee.

Chapter V.—THE MINES.

The colonisation of Victoria was thus undertaken, owing to the suitability of the country for pastoral pursuits. But its prosperity was assured by the gold discoveries, which practically began in 1851. The chief goldfields were all found and developed within ten years of the first important discoveries; and the fame of their wealth led to a great increase in the population, and a rapid development of the country.

Mining fields are subject to great variations of fortune, and, except when a mining field occurs in a district with good agricultural resources, its population and prosperity may be temporary. The now deserted

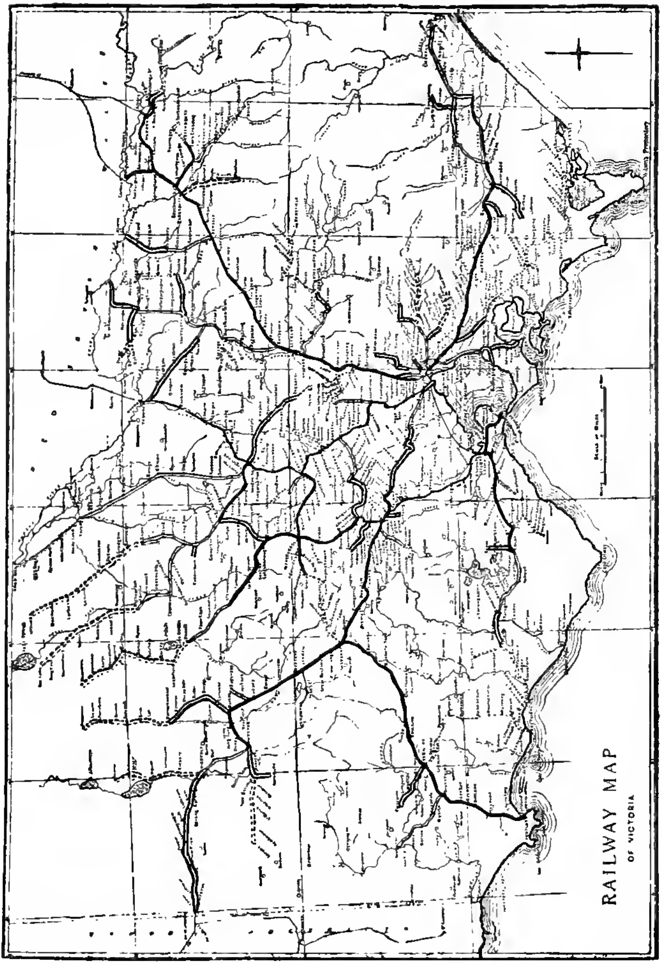
town of Grant, for example, had a population of over twenty thousand at the end of the fifties.

Hence, the development of the mining industry helped to maintain the apparently excessive importance of Melbourne in Victoria, in spite of the fact that it is not in a mining district. Rather than settle in a township like Grant, which might at any time collapse, men preferred to work at the mine, and make their homes in a residential centre. Hence, we get the apparent anomaly of nearly half the population of Victoria, essentially a country of scattered industries, being concentrated in Melbourne. We must not forget that the position of Melbourne in Victoria is quite different from that of London in England. London is the child of England. It was a mere group of fishermen's huts when Colchester and Chichester were towns. The Romans chose it as their capital, to administer the affairs of the scattered provincial population; but Melbourne is the father, and not the child, of Victoria. The country settlements, in the main, arose as offshoots from Melbourne.

The importance of geographical factors in determining the movements of the population is clearly shown by railway development.

Chapter VI.—THE RAILWAYS.

The influence of geographical factors on the progress of settlement in Victoria is clearly shown by the advance of the railways. The railway development may be divided into seven periods—1854-60, 1861-71



Railways built between 1854 and 1860
1861 1871
1872 1879
Railways built between 1880 and 1884
1885 1889
1890 1892
1898 1902

Fig. 116.

1872-79, 1880-84, 1885-89, 1890-92, and **1893-1902.** The railways in the first period, from 1854-60, include some suburban lines, beginning with that to Port Melbourne in 1854. The early importance of Geelong as the port of the western squatters, and the ease with which a railway could be laid over the level basalt plains, led to the first non-suburban line being that from Williamstown to Geelong, opened in 1857. But, as the sudden inrush of wealth to the colony was due to the mining industry, the construction of a line to Bendigo was at once begun, and, by the end of 1860, it had reached as far north as Sunbury. The period from 1861-71 was marked by the completion of the line through Bendigo to Echuca (1861-62) ; owing to the steepness of the scarp of the Ballarat plateau west of Bacchus Marsh, railway communication to Ballarat was opened (1862) from Geelong. The first great work of the third period (1872-79) was the building (1872-73) of the Victorian section of the line to Sydney. The line to Adelaide was of less political importance, and, though it was begun in 1874, it reached the South Australian border only in 1887. The rest of the railway lines of the seventies included a series of local lines for the development of the mining districts round Ballarat and Maryborough, reaching as far to the north-west as St. Arnaud (1878). The other three lines of this period were for the development of the agricultural districts of southern Victoria; they ran from Melbourne to Sale, from Ararat to Portland, and from Geelong to Colac. The period 1880-84 was marked by the attempts to extend agricultural settlement into the north-western plains. The St. Arnaud line was extended to Donald, the line

from Inglewood to Wycheproof and Boort, and a line from Bendigo as far as Kerang. The lower Goulburn was opened by the Goulburn Valley line, and the line from Tallarook to Yea was the first stage in the advance of the railways into the basin of the upper Goulburn.

1885-89 shows three principal developments. The opening of the coalfields in Gippsland led to the railway branches off the Sale line to Mirboo and Thorpedale, and the beginning of the great southern line, which was carried as far as Tooradin. The direct line from Melbourne to Ballarat was completed, and cross lines, connecting many of the provincial towns, such as Inglewood and Dunolly, Bendigo and Heathcote. The Sale line was extended to Bairnsdale, and the approach of the famous land boom was indicated by the number of the local lines around Melbourne. With them may be grouped the Stony Point line, giving quick communication to the fishing industry of Western Port, as it was mainly for the convenience of Melbourne. Between 1890 and 1892 the chief railways constructed were those connecting Warrnambool and Hamilton, Bendigo and Kilmore, Ararat and Avoca, each traversing country mainly of agricultural value. The completion of the line from Kerang to Swan Hill gave easier access to the plains along the Murray; the completion of the line along the upper Goulburn to Mansfield was no doubt largely due to the mining success at Wood's Point.

After the financial crisis of 1892, railway development was retarded, but the opening of the Mallee plains of north-western Victoria led to the pushing into that country of five parallel lines of railways.

Thus the line was opened from Dimboola to Rainbow in 1899, from Murtoa to Hopetoun in 1894, from St. Arnaud to Woomelang in 1899, from Inglewood to Sealake in 1895, and to Ultima in 1900.

Thus, generally stated, railway development began with a series of local lines round Port Phillip, and then opened communication with the three chief early mining centres—Bendigo, Castlemaine, Ballarat; next came the lines of communication with Sydney and Adelaide, and the development of the principal mining areas by branch lines; finally, the agricultural country of southern Victoria was opened up by lines to Bairnsdale and Portland, and the north-western plains by the five long Mallee lines.

Chapter VII.—IRRIGATION AND WATER SUPPLY.

Irrigation in Victoria has made less progress than railway development, because the country presents unusual difficulties to wide-spread irrigation. Successful irrigation requires three conditions. There must be an abundant and reliable supply of water; the water must be available at the season of the year when it is most useful to the agriculturist; and it requires a sufficiently crowded population to yield enough careful and patient labour, for the water to be used to the best advantage.

Irrigation has long been successful in India, China, and Egypt, because those countries have the necessary requirements. In Egypt, for example, there is a

crowded population of Felahin, who are patient agriculturists; and they receive an unfailing supply of water in autumn, at the time when it is of most use.

Irrigation is successful in China, because the country enjoys the same advantages; and the Chinese boast that their civilization supports, in comfort, a denser population than any other civilization the world has known.

There have been in Victoria many successful applications of irrigation. But they have been either on a comparatively small scale, as at Bacchus Marsh, or close to the abundant waters of the Murray, as at Mildura. The attempt to irrigate the arid, north-western plains of Victoria, by water brought from distant parts of the State, is attended with greater difficulties.

The irrigation settlement at Mildura was established by two Canadians, the Chaffey brothers, in the far north-west of Victoria, on the southern bank of the Murray River. The Chaffey brothers received a concession, practically in perpetuity, of as much water from the Murray, as was required for the irrigation of 250,000 acres, and for the service of as many inhabitants as might settle there. The firm received a block of 50,000 acres free, and the remaining 200,000 acres on generous terms. Work was begun at Mildura in August, 1887. Pumping engines were erected at many points along the bank of the Murray; hundreds of miles of channels were dug for the distribution of the water, extensive plantations of vines and fruit trees established. The settlers bought plots of land from the proprietors, who supplied them with

water sufficient to cover the land every year to a depth of 15 inches, at a cost of about 12s. per acre.

For some years the colonists had to struggle against adversity; but, largely owing to the cultivation of raisins and other dried fruits, the success of the experiment has now been established beyond question.

The earliest extensive irrigation in Victoria was in the lower part of the Loddon Valley, which admitted of comparatively easy irrigation, as in places the land is lower than the flood level of the Murray. In fact, banks had to be built to protect the land from floods. The ground was irrigated either by allowing the water to flood the fields, or it was raised to the necessary height by steam pumps. By 1892, over 12,000 acres in the lower Loddon and the Gunbower district beside the Murray were being irrigated. More than half of this land was used for growing wheat.

In western Victoria, in the country known as the Wimmera District, an extensive series of water channels has been made to irrigate that country, for much of it has a rich soil, but a low and uncertain rainfall. As the Wimmera itself is an unreliable and often insignificant river, a great storage reservoir has been constructed at Wartook, near the head of the Mackenzie River; the reservoir has a capacity of sixteen million cubic feet. A series of channels distribute a sufficient amount of water for household purposes and for watering stock. The amount used for irrigation has been small. In 1892, the maximum area watered was only 15,000 acres, nearly all of which was used for the growth of wheat. Much trouble has been experienced with these channels, owing to their becoming partially filled up by sand.

The waters of Victoria are controlled by four bodies:—The Water Supply Branch of the Mines Department, which controls the great national works, the Metropolitan Board of Works, which manages the Melbourne water supply, the Provincial Water Works Trusts, and the Irrigation Trusts. The Melbourne water supply was first obtained from the Plenty River, the surplus flow of which is stored in the Yan Yean reservoir (opened in 1858); the amount thus obtained was increased by bringing the waters from some of the tributaries of the Goulburn, over the gap in the watershed east of Mount Disappointment. The Plenty Valley supply is now supplemented by that obtained from the large reserve around the Watts River, north-east of Healesville; this water is brought to Melbourne by the Maroondah aqueduct, which was finished in 1890.

Water Trusts are a group of bodies to whom Parliament has granted the control of the water of many areas, for the supply of towns, or for stock on farms. There are now fifteen Water Works Trusts, of which one, the Echuca and Waranga Water Trust, has now practically developed into an Irrigation Trust.

The fourth group of bodies concerned in the Victorian water supply are the Irrigation Trusts. They are authorized to take water from various sources for irrigation, charging the consumers for the water supplied. There are now twenty-three Irrigation Trusts. Most of these Irrigation Trusts have made their works with money lent them by Government, in the expectation that the works would prove remunerative, and the Trusts would be able to repay their debts. But owing, in some cases to the small

supply of water available when wanted, in other cases to the inadequate supply of labour for the employment of water in intense culture, the Trusts have been unable to meet their responsibilities. In the case of the Wimmera Trust, which includes the largest area, the works are now used only for the supply of towns and household requirements.

The Trusts have not been financially successful, and were relieved of most of their liabilities by an act of Parliament (the Irrigation and Waterworks Trusts Relief Act) in 1899. Thus the Rodney Trust, one of the most favourably situated, owed the State £265,000, of which a little over £200,000 was remitted. Altogether, of the £2,500,000 that had been borrowed from the State for water schemes, the amount of £1,650,000 was forgiven.

Of the National Works the most important is the great weir across the Goulburn River, near Murchison. The Goulburn is the largest of the Victorian rivers, and in the winter and spring it sends down an enormous flow of water, amounting in one year to 168,000,000,000 gallons. Most of the water in great floods runs to waste. Another national storage reservoir is now being built at Waranga, 26 miles from the Goulburn reservoir. It will be filled by the surplus overflow from the Goulburn, which the present reservoir cannot keep; a number of channels to be constructed from this reservoir will carry the water to the north-west into the valleys of the Campaspe and the Loddon. A channel from the Goulburn reservoir takes its water northward into the area controlled by the Rodney Irrigation Trust; where it is distributed by a network of channels. The remaining national

works are the reservoirs at Casey's and Gowangardie Weirs on the Broken River, which supply the Shepparton and Tungamah Water Trusts; the storage reservoir at Kow Swamp, with its intake channel from the Murray, and its outlet, Macorna Channel, traversing the Tragowel Plains; the channels distributing the water pumped up from Long Lake, near Swan Hill; a series of channels in the Mallee country between Lakes Buloke and Tyrrell; and a reservoir at Lake Lonsdale to store water from the western Wimmera.

The flow of the Loddon River is controlled by three National Works—the Laanecoorie, Bridgewater, and Kinypanial Weirs; the chief of these is the Laanecoorie Weir, sixteen miles above Bridgewater. The reservoir behind the weir holds nearly four thousand million gallons of water. The water from the Loddon is used by a series of Water Works and Irrigation Trusts.

In the neighbourhood of Castlemaine and Bendigo an extensive series of Water Works was established between 1865 and 1870, at the cost of a million sterling. Most of the water is obtained from the Coliban River by two reservoirs near Malmesbury; the lower, or Malmesbury Reservoir, is capable of holding over three and a quarter million gallons. Some smaller reservoirs help on the distribution of the water from the Malmesbury Reservoir, and also catch small local supplies. The main object of this water supply scheme was to supply the mines at Castlemaine and Bendigo. It distributed water to many towns in the Castlemaine and Bendigo districts, and to some small irrigated areas, *e.g.*, the orchards

along the banks of Barker's Creek, between Castlemaine and Bendigo, and along the Emu and other creeks, south-east of Bendigo.

The most ambitious of the Victorian water supply projects is a proposal to irrigate the Mallee country from the upper Murray. Most of the Mallee country is so high above the level of the nearest part of the Murray, that it would be impracticable to raise the water therefrom. There is no nearer river that would yield an adequate supply. The Wimmera, the only river to the south, is too small to be of any practical value. The Loddon and the Campaspe are both too small to water their own valleys. The whole of the spare waters of the Goulburn can be used up in the plains of the lower Goulburn, and in places between that river and the Loddon. The only river that has water far in excess of its own local needs is the upper Murray, above Albury. It is, therefore, proposed to build a big reservoir in the upper Murray, and carry the water by a long channel across Victoria into the Mallee. The authors of the scheme estimate that it would supply the residents in the Mallee country with sufficient water for household purposes, watering stock, and for the irrigation of one acre in every four square miles of the country.

Chapter VIII.—FUTURE DEVELOPMENT.

The progress of Victoria in the past has, therefore, been largely guided by geographical factors; and we may expect that the same factors will mould its

future progress. Predictions on such a subject are sure to be wrong, unless they allow for the obstinate stubbornness of the average Briton; he may start an industry for which his district is economically most unsuitable; yet he may carry his scheme to partial, or even complete success, by resolute refusal to know when he is beaten.

Looking at the geographical factors, we see that Victoria has in the first place a vigorous and bracing climate. Commercial institutions which have establishments both in Melbourne and Sydney pay, I am told, higher nominal wages in Melbourne than in Sydney. It is said that the task wages are much the same in both towns, but the nominal rates of Melbourne are higher, owing to the greater efficiency of the workers in our more vigorous climate. The superiority of our southern climate would make Melbourne a suitable and economical administrative centre. I am not suggesting for a moment that Melbourne should be, or will be the seat of Federal Government; for that question will not be settled by considerations of scientific geography. But as far as concerns private business, Melbourne may develop as the administrative centre. And if the spirit of state patriotism should decline with the growth of federal patriotism, Victoria, thanks to its pleasing climate, may become more and more the residential centre of Australia. As a manufacturing city, however, Melbourne is heavily handicapped by the expense of fuel. Sydney, owing to its proximity to the great coalfield of New South Wales and the existence of proved coal seams beneath the city, has an inestimable advantage as a manufacturing centre. The abolition

of the State customs duties should help in time to make the area between Sydney and Newcastle the manufacturing metropolis of Australia.

Victoria, with its vast sources of mineral wealth, its wide tracts of rich grazing country on the basaltic plains, its long well-watered hill ranges, with their rich felspathic mudstone soil, has an assured future as a mining, pastoral, and agricultural country. So, looking at the country purely from the point of view of its easiest economic development, we should expect, from geographical considerations, that Melbourne would become a residential, administrative, and distributive centre; while Victoria would develop as a mining, pastoral, and agricultural country; whereas our manufactures would remain of secondary importance. We must remember, however, that this represents only the natural lines of progress; whether the country will develop along those lines is an altogether different matter. That Nature proposes, but the resolution of man disposes, is the fundamental principle in the study of applied political geography.

APPENDIX I.

TABLE OF STRATIFIED ROCKS OF VICTORIA.

Kainozoic—the Period of Recent Life—(Characterised by the remains of animals and plants allied to living types).

Upper Kainozoic.—The flood plains of existing rivers; raised beaches; sand dunes; dune limestones, around Warrnambool, the Sorrento Peninsula, etc.

The marine beds along the lower Glenelg River; the clays and volcanic tuffs with the bones of giant marsupials at Geelong, Lake Kolongulac, Buninyong, etc.

The newer basalts of Victoria and the craters of Tower Hill, Mounts Leura, Elephant, Buninyong, Warrenheip, etc., etc.

The high level gold drifts and the deep leads.

Lower Kainozoic.—Sands, clays, and limestones with marine fossils near Geelong and along the Moorabool Valley, also at Beaumaris, Mornington, Royal Park (Melbourne), Bairnsdale, Jemmy's Point (Lakes Entrance), Muddy Creek, Stawell, etc., etc.

The older basalts at Flemington, Bacchus Marsh, south-western plains of Victoria, Dargo High Plains, Mount Table Top, Tanjil and southern Gippsland, etc.

The clays with iron stones, containing fossil leaves at Flemington and the Parwan Valley, near Bacchus Marsh. The gravels and clays at the Dargo and Kobungra High Plains. The brown coals of the Mallee, Melton, Altona Bay, and the Latrobe Valley.

Mesozoic—the Period of Middle Life—(Characterised by the remains of animals and plants of a more primitive type than those of the Kainozoic).

Cretaceous.—No known Victorian representative.

Jurassic.—The carbonaceous mudstones of the hills beside the Wannon, the Otway Ranges, Barrabool Hills near Geelong, and the mountains of southern Gippsland. These mountains contain abundant leaves of land plants and ferns, and the remains of fresh water fish and teeth of extinct reptiles.

This series contains the coal seams of the Otway Ranges and southern Gippsland.

Triassic.—No known Victorian representatives.

Palaeozoic—the Period of Ancient Life—(Characterised by the remains of animals and plants of primitive types).

Carboniferous, UPPER.—5. The sandstones of Bacchus Marsh, with the leaves of Gamgamopteris.

MIDDLE.—4. The glacial deposits and boulder clays at Bacchus Marsh, Heathcote, Bendigo, Chiltern, the Loddon Valley, Euroa, and southern Gippsland.

LOWER.—3. The Grampian sandstones, the Cathedral sandstones, and the sandstones of Mount Wellington.

2. Bedded standstones near Mansfield with fish remains.

1. The Avon River sandstones with remains of the plant Lepidodendron.

Devonian, UPPER.—The sandstones and conglomerates of Iguana Creek.

MIDDLE.—The limestones and shales of the Snowy River, Bindi, and Buchan. The Tabberabbera shales.

LOWER.—The Snowy River porphyries and various igneous rocks.

Silurian, YERINGIAN.—Sandstones, slates, and limestones at Lilydale, Yering, Loyola, Thomson River, Cape Liptrap, etc.

MELBOURNIAN.—Sandstones, quartzites, and slates at Melbourne, the Upper Yarra, Heathcote, etc.

Ordovician, UPPER.—4. Darriwell beds.

LOWER.—3. Castlemaine beds.

2. Bendigo beds.

1. Lancefield beds.

Cambrian, HEATHCOTIAN.—Altered cherts (jasperoids) and shales generally associated with diabase and other altered basic igneous rocks; at Stavelly; west of Geelong; east of Colbinabbin Range; Heathcote; Mount William, near Lancefield; east of Walhalla; Cape Liptrap, etc.

Archean—the Period earlier than any known remains of life.

Archean.—Schists, gneisses and granites of north-eastern Victoria, and of the Dundas Highlands in the west.

APPENDIX II.

EARTHQUAKES RECORDED IN VICTORIA DURING 1900 AND 1901.

Greenwich Mean.—Civil Time.		Place.	Description of Phenomena.
1900			
Feb. 24	2.45 p.m.	Armadale and Toorak	Made house and furniture quiver. Came from S.E. direction. Lasted 4 to 6 secs.
Mar. 11	Between 5 h. 30m. p.m. and 6 h.	Warrnambool	Slight shock.
Sept. 16	About 3 p.m.	Warrnambool	Slight tremor.
May 26	0 or 12 h. p.m.	Mansfield	Distinct shock. Direction N. to S.
27	2 h. 30 m. p.m.	Warragul	Shock appeared to travel from E. to W. Lasted 35 secs. Motion appeared to be perpendicular and severe in certain localities; the intervening ground was but little affected.
		Carbethon (Warragul)	Tremor. House shook and window rattled. Course seemed to be E. and W.
	2 h. 30 m. p.m.	South Yarra, Punt Hill	Shock felt. Motion "up and down."
	2 h. 33 m. p.m.	South Yarra, Melbourne (Collins Street), East Melbourne	Shock.
	About 2 h. 30 m. p.m.	South Yarra, St. Kilda	Shock.
	2 h. 25 m. p.m.	Grantville	Distinct shock, lasting several seconds. Loud rumbling noise.

EARTHQUAKES RECORDED IN VICTORIA DURING 1900 AND 1901—*continued.*

Greenwich Mean.—Civil Time.		Place.	Description of Phenomena.
1900 May 27	2 h. 25 m. p.m.	Korumburra	Loud rumbling noise followed by severe shock, lasting over 6 secs. Severe tremor. Apparently travelling W. to E. Rolling motion. Noise as of thunder. People left houses.
	2 h. 30 m. p.m.	Leongatha	Slight earth tremor.
	2 h. 30 m. p.m.	Camberwell	Shock appeared to travel towards E. Jug in basin on washstand moved several times.
	2 h. 30 m. p.m.	Brunswick	Shock. Noise resembling gale of wind. Rocking motion. Produced feeling akin to sea sickness.
	2 h. 30 m. p.m.	Beaconsfield	Sharp shock, lasting about a minute.
	2 h. 30 m. p.m.	Dandenong	Distinct shock. Lasted about 6 secs. Rattled several residences.
	About 2 h. 30 m. p.m.	Drouin	Severe shock. Appeared to travel from N.W. Buildings shaken.
	2 h. 30 m. p.m.	Fern Tree Gully	Distinct shock.
	About 2 h. p.m.	Foster	Two distinct tremors in quick succession, lasting fully 15 secs. Houses shook. Crockery, &c., rattled. People hurriedly left houses.
	Shortly after 2 h. p.m.	Jeetho	Very severe shock, causing houses to shake, and empty railway truck on siding to rattle loudly.

2 h. 30 m. p.m.	Cumberoona	Earthquake slight.
About 2 h. 25 m. p.m.	Jumbunna	Severe shock. Appeared to travel from W. to E. Two great thuds, making houses almost rock. Roar like explosion deep below surface. People left houses. Produced headaches and feeling of sea sickness. Quantity material displaced in Jumbunna Mine.
2 h. 15 m. p.m.	Outtrim	Decided shock. Apparently travelled N.E. to S.W. Shook houses and furniture, and broke ornaments on mantelpieces. Severely felt in mine. Duration 8 to 10 secs.
About 2 h. 30 m. p.m.	Pakenham	Pronounced shock, lasting 28 to 30 secs.
About 2 h. 30 m. p.m.	Poowong	Distinct shock over district. Windows and doors rattled.
	Poowong North	Church shook as people were leaving after morning service. Lamps swayed to and fro.
2 h. 30 m. p.m.	Sassafras	Sharp shock. Made houses creak. Shook articles off shelves. Lasted about 10 secs.
1 h. 45 m. p.m.	Stony Creek	Severe shock, lasting nearly 10 secs. Report.
2 h. 42 m. p.m.	Archie's Creek (*via* Grantville)	Tremor. Duration 10 secs. Direction from S.E. to N.W. Sound resembling distant thunder.
2 h. 30 m. p.m.	Krowera	Shock. Lasted about 15 secs. Appeared to travel from S. to N. Houses shaken. Crockery rattled. Books thrown from shelves.
2 h. 30 m. p.m.	Jindivick	Slight shock.
About 2 h. 30 m. p.m.	Garfield	Strong shock.
2 h. 30 m. p.m.	Narre Warren	Earthquake W. to E.
2 h. 30 m. p.m.	Ardeen	Houses shook. Crockery rattled.
About 3 h. p.m.	Beenak	Earthquake E. to W.

EARTHQUAKES RECORDED IN VICTORIA DURING 1900 AND 1901—*continued.*

Greenwich Mean.—Civil Time.		Place.	Description of Phenomena.
1900 May 27	2 h. 30 m. p.m.	Bunyip South	Violent earthquake, lasting about 30 secs Rumbling sound like thunder. Place shaken violently, producing feeling of nausea. Direction from W. to E.
June 5	Between 10 h. & 10 h. 30 m. a.m.	Meredith and Steiglitz	Distinct shock, lasting 2 or 3 secs. Buildings vibrated. Rumbling sound.
	Between 10 & 11 h. a.m.	Anakie	Oscillation of buildings. Lasted several minutes.
Sept. 4	9 h. 10 m. a.m.	Jamieson	Heavy shock, lasting about 10 secs. Travelling from N.W. to S.E.
Oct. 8	4 h. 48 m. a.m.	Myrtleford	Slight shock.
	4 h. 45 m. a.m.	Cheshunt	Slight shock
		Princetown	
June 15		Rivernook	Distinct shock. Houses slightly shaken. Loud noise like double clap of thunder, lasting 30 secs. Appeared to be travelling westward.
1901 Nov. 18	About 4 p.m.	Walhalla	Rumble of earthquake.
19	3 w. 40 m. p.m.	Walhalla	Distinct shock, travelling N.W.
	3 w. 40 m p.m.	Moondarra	Very severe shock. Several barns and sheds destroyed.

APPENDIX III.

(By Mr. Baracchi).

No. 1.

TABLE SHOWING DECREASE OF RAINFALL WITH INCREASED DISTANCE FROM THE COAST LINE.

Annual Rainfall.

	in.		in.		in.
Cape Otway	34·67			Gabo	38·50
Portland ...	33·08	Melbourne	25·57	Sale	24·40
Hamilton ..	26·73	Bendigo ...	21·83	Wangaratta	23·83*
Nhill ...	16·87	Echuca ...	17·07	Omeo... ...	26·07*
Mildura ...	10·91			Beechworth...	32·09*

*Also showing increase of rainfall with increased altitude.

No. 2.

AVERAGE ANNUAL RAINFALL.

North-west Quarter	Extreme north-west, north of Parallel 36°	14·00 in
	Between Parallel 36° and 37° 30′	20·00 ,,
South-west ,,	... ...	30·00 ,,
North-east ,,	... ...	32·00 ,,
South-east ,,	... ...	34·00 ,,

No. 3.

TABLE SHOWING VARIATION IN THE AVERAGE ANNUAL RAINFALL AT DIFFERENT LOCALITIES IN THE NORTHERN SLOPE OF THE STATE, DUE TO ELEVATION AND OTHER PURELY TOPOGRAPHICAL CONDITIONS.

Average Annual Rainfall.

Districts along the Murray ...	from	12 inches	to	59 inches.	
Basin of the Mitta Mitta	,,	28	,,	45	,,
,, ,, Ovens	,,	25	,,	67	,,
,, ,, Goulburn	,,	15	,,	56	,,
,, ,, Campaspe ...	,,	17	,,	40	,,
,, ,, Loddon	,,	11	,,	45	,,
,, ,, Avon and Richardson .	,,	14		17	,,
,, ,, Avoca	,,	13	,,	21	,,
,, ,, Wimmera East ...	,,	15	,,	35	,,
,, ,, Wimmera West ...	,,	13	,,	24	,,
Mallee Country	,,	9	,,	18	,,

No. 4.

MONTHLY AVERAGES AND EXTREMES OF TEMPERATURES AND RAINFALL FOR REPRESENTATIVE PLACES IN VICTORIA.

STATION.	JANUARY. Temperature of Air in Shade. In degrees. Mean.	Extremes on Record. Max.	Min.	Mean Humidity.	Average Rainfall.	FEBRUARY. Temperature of Air in Shade. In degrees. Mean.	Extremes on Record. Max.	Min.	Mean Humidity.	Average Rainfall.	MARCH. Temperature of Air in Shade. In degrees. Mean.	Extremes on Record. Max.	Min.	Mean Humidity.	Average Rainfall.	APRIL. Temperature of Air in Shade. In degrees. Mean.	Extremes on Record. Max.	Min.	Mean Humidity.	Average Rainfall.
Mildura ...	76.6	120.0	42.0	—	0.60	78.4	120.0	43.0	—	0.51	70.5	115.5	39.0	—	0.61	62.9	99.0	37.0	—	0.81
Nhill ...	68.7	111.0	32.0	—	0.78	72.9	110.0	40.0	—	0.49	63.8	101.0	35.0	—	1.08	57.5	94.0	32.0	—	1.75
Hamilton ...	65.5	110.0	40.0	—	1.37	66.1	106.0	40.0	—	0.88	62.0	101.0	40.0	—	1.72	55.9	89.0	36.0	—	2.17
Portland ...	64.4	108.0	40.0	0.74	1.53	64.8	105.0	38.0	0.74	1.03	—	100.0	37.0	0.74	1.63	59.9	90.0	35.0	0.78	2.76
Cape Otway	60.8	109.0	38.0	0.84	2.00	61.4	105.0	39.0	0.82	1.49	60.3	105.0	30.0	0.82	2.17	57.1	92.0	35.0	0.83	2.73
Echuca ...	74.5	115.0	40.0	0.57	0.82	73.4	113.0	42.0	0.53	1.01	68.6	105.0	38.0	0.59	1.27	60.1	95.0	31.0	0.66	1.65
Bendigo ...	71.9	117.4	37.0	0.52	1.43	71.1	111.6	41.4	0.54	1.11	66.8	104.5	38.2	0.60	1.49	59.1	94.7	34.0	0.71	1.89
Melbourne	66.2	111.2	42.0	0.64	1.91	66.4	109.0	40.3	0.65	1.72	63.8	105.5	37.1	0.68	2.06	58.6	94.0	34.8	0.73	2.48
Gabo ...	63.9	95.0	41.0	0.85	2.64	64.5	90.0	43.0	0.85	3.23	63.8	97.0	38.0	0.85	2.49	60.5	86.0	37.0	0.85	3.38
Sale... ...	65.3	109.0	44.0	0.66	2.00	67.1	108.0	42.0	0.65	1.63	63.4	103.0	40.0	0.70	1.70	57.8	92.0	34.0	0.78	2.60
Omeo ...	65.1	107.5	31.0	0.57	1.70	64.5	107.0	28.0	0.67	2.45	60.3	103.0	29.0	0.75	1.71	53.7	88.2	22.0	0.78	2.00
Beechworth	70.2	111.0	31.0	—	1.63	68.8	105.0	37.0	—	1.99	65.0	99.0	34.5	—	2.52	56.5	90.0	30.0	—	2.55
Wangaratta	74.4	110.0	40.0	—	1.41	73.9	108.0	40.0	—	1.64	68.5	104.0	39.0	—	2.09	60.3	95.0	32.0	—	2.24

MONTHLY AVERAGES AND EXTREMES OF TEMPERATURES AND RAINFALL FOR REPRESENTATIVE PLACES IN VICTORIA *continued.*

Station.	May.					June.					July.					August.				
	Temperature of Air in Shade. In degrees.			Mean Humidity.	Average Rainfall	Temperature of Air in Shade. In degrees.			Mean Humidity.	Average Rainfall	Temperature of Air in Shade. In degrees.			Mean Humidity.	Average Rainfall	Temperature of Air in Shade. In degrees.			Mean Humidity.	Average Rainfall
	Mean.	Extremes on Record. Max.	Extremes on Record. Min.			Mean.	Extremes on Record. Max.	Extremes on Record. Min.			Mean.	Extremes on Record. Max.	Extremes on Record. Min.			Mean.	Extremes on Record. Max.	Extremes on Record. Min.		
Mildura ...	55·5	96·0	30·0		0·97	51·1	84·0	26·0	—	1.63	49·3	85·0	28·5		0·93	52·8	85·0	31·0		1.25
Nhill ..	51·6	83·0	28·0	—	1·68	47·1	68·0	25·0	—	2·38	46·1	71·0	23·0		1·52	48·0	76·0	26·0	—	1·83
Hamilton ...	51·0	75·0	28·0	—	2·54	47·7	61·0	20·0	-	3·26	45·0	63·0	25·0		2·72	47·7	69·0	20·0	—	3·09
Portland ...	55·8	80·0	31·0	0·80	3·69	53·0	70·0	27·0	0·81	4·02	51·3	68·0	27·0	·81	4·09	52·9	78·0	30·0	·70	4.20
Cape Otway	54·0	81·0	35·0	0·83	3·54	51·2	72·0	36·0	0·84	4·04	49·1	70·0	34·0	·84	3·30	50·3	75·0	34·0	·83	3·68
Echuca ...	52·8	83·0	28·0	0·72	1·62	49·3	71·0	28·0	0·78	2·06	47·2	78·0	23·0	·80	1·23	50·0	78·0	24·0	·79	1·97
Bendigo ...	52·1	80·0	30·5	0·77	2·12	47·6	77·3	28·3	0·84	2·76	45·6	73·0	27·5	·82	1·86	48·6	73·2	29·0	·76	2·29
Melbourne	53·2	82·1	31·3	0·78	2·16	49·7	68·1	28·0	0·80	2·03	47·0	68·4	27·0	·80	1·87	50·4	77·0	28·3	·75	1·81
Gabo ...	56·0	84·0	33·0	0·85	4·25	52·8	83·0	32·0	0·84	4·17	50·7	80·0	31·0	·83	3·57	51·7	79·0	32·0	·81	2·91
Sale	52·6	78·0	29·0	0·78	2·30	49·0	71·0	27·0	0·81	2·11	47·2	71·0	27·0	·79	1·71	49·9	71·0	28·0	·78	2·46
Omeo ...	46·0	82·0	20·0	0·84	2·10	42·7	70·0	17·0	0·90	2·48	40·4	69·0	16·5	·87	1·80	43·3	75·0	10·0	·87	2·16
Beechworth	49·1	77·0	27·0	—	3·16	44·5	67·0	24·0	—	3·90	42·4	65·0	26·0	—	3·01	45·5	70·0	27·0		3·25
Wangaratta	52·7	79·0	28·0	—	2·21	49·0	72·0	26·0	—	3·04	47·2	70·0	26·0	—	2·06	50·0	77·0	27·0	—	2·61

Station.	September.					October.					November.					December.				
	Temperature of Air in Shade. In degrees.			Mean Humidity.	Average Rainfall.	Temperature of Air in Shade. In degrees.			Mean Humidity.	Average Rainfall.	Temperature of Air in Shade. In degrees.			Mean Humidity.	Average Rainfall.	Temperature of Air in Shade. In degrees.			Mean Humidity.	Average Rainfall.
	Mean.	Extremes on Record. Max.	Extremes on Record. Min.			Mean.	Extremes on Record. Max.	Extremes on Record. Min.			Mean.	Extremes on Record. Max.	Extremes on Record. Min.			Mean.	Extremes on Record. Max.	Extremes on Record. Min.		
Mildura ...	69·2	94·0	29·0	—	0·75	64·6	102·0	35·0	—	1·11	72·2	112·0	30.0	—	0·80	76·7	115·0	41·0	—	0·94
Nhill ...	63·0	83·0	29·0	—	1·62	68·2	94·0	31·0	—	1·79	65·5	107·0	36·0	—	1·02	68·7	114·0	35·0	—	0·93
Hamilton ...	61·8	78·0	33·0	—	2·76	54·7	90·0	33·0	—	2·63	59·3	103·0	34·0	—	1·93	63·0	111·0	36·0	—	1·66
Portland ...	54·7	83·0	30·0	·77	3·43	57·2	95·0	34·0	·77	2·73	59·5	102·0	36·0	·77	1·84	61·9	105·0	37·0	·75	1·83
Cape Otway	51·0	82·0	30·0	·84	3·51	53·0	91·0	31·0	·87	3·13	56·4	103·0	34·5	·84	2·45	58·4	105·0	35·0	·85	2·03
Echuca ...	54·3	89·0	28·0	·74	1·36	60·2	99·0	27·0	·67	1·65	67·2	106·0	30·0	·57	1·41	71·3	110·0	35·0	·58	1·02
Bendigo ...	52·0	84·0	30·0	·73	2·12	57·5	99·7	32·0	·69	2·35	64·3	106·5	36·0	·59	1·54	68·6	111·5	40·0	·63	1·24
Melbourne	63·1	81·8	32·1	·72	2·30	56·6	96·1	32·1	·70	2·75	60·4	105·7	36·5	·67	2·28	63·7	110·7	40·0	·64	2·20
Gabo ...	63·6	84·0	32·0	·84	2·94	55·9	93·0	36·0	·87	3·13	58·9	94·0	35·0	·85	2.74	61·4	100·0	39·0	·86	2·25
Sale	52·6	81·0	29·0	·74	2·25	56·2	92·0	34·0	·75	2·03	61·4	102·0	36·0	·66	1·75	64·4	110·0	40·0	·65	1·86
Omeo ...	48·0	79·0	23·0	·80	2·41	53·2	92·0	26·0	·79	2·80	68·8	101·0	28·5	·68	2·24	62·0	105·0	31·0	·64	2·22
Beechworth	49·3	81·0	28·0	—	3·15	65·3	94·0	29·0	—	2·85	61·1	100·0	32·0	—	2·30	65·9	105·0	36·0	—	1·66
Wangaratta	54·7	87·0	30·0	—	2·35	59·9	98·0	32·0	—	2·36	66·9	103·0	37·0	—	1·90	71·7	108·0	30·0	—	1·48

Monthly Averages and Extremes of Temperatures and Rainfall for Representative Places in Victoria—*continued.*

Mount St. Bernard.

Month	Temperature of Air in Shade. In degrees. Mean.	Extremes on Record. Max.	Extremes on Record. Min.	Mean Humidity.	Average Rainfall
JANUARY.	64·3	94·0	27·0	—	4·69
FEBRUARY.	57·7	89·0	28·0	—	3·73
MARCH.	52·9	78·0	26·0	—	4·86
APRIL.	45 2	69·0	22·0	—	5·79
MAY.	40·1	67·0	17 0	—	5·51
JUNE.	34·8	61·0	19 0	—	10·96
JULY.	33·5	57·0	17·0	—	5·45
AUGUST.	35·2	5·58	19·0	—	5·72
SEPTEMBER.	39·3	65·0	21·0	—	5·73
OCTOBER.	43·0	75·0	17·0	—	6·15
NOVEMBER.	49·6	80·0	24·0	—	4·39
DECEMBER.	53·4	86·0	26·0	—	4·05

LIST OF ILLUSTRATIONS.

GLOSSARY, AND INDEX TO TECHNICAL TERMS.

The numbers refer to pages.

A-a, 183
Agglomerate, 184
Alluvial. Loose deposits, such as sand, clay, or gravel, washed together by rain or rivers.
Alluvium. Surface soil formed from alluvial deposits.
Anabranch, A branch of a river which leaves it and joins it again.
Antecedent, 105
Anticyclone, 214
Ash, 184

BASALT. A lava, rich in iron, magnesia, and lime, and poor in silica.
Beheading, 103
Betrunking, 120
Billabong, 154
Block mountains. Mountains formed of blocks of rocks, which have been uplifted in mass, or left standing as mountains by the removal, generally by sinking, of the surrounding country.
Bomb, 184
Breached crater, 182, 189
Broad, 144
Buttes, 54
Buys-Ballot's Law, 216

CAINOZOIC, see Kainozoic
Caldera, 130 note, 181
Carbonaceous. Containing coal or carbon.
Carbonic dioxide. A gas consisting of carbon and oxygen.
Cement. A band of gravel cemented into a hard rock, generally by iron or stone; it is found on the Victorian alluvial goldfields.
Centrosphere. The internal mass of the globe.
Chainon, 60
Chert. A compact bedded rock, composed of silica. It may be made up of the remains of silicious sponges, or of other animals that have siliceous skeletons; or it may be deposited by chemical action.
Cirrus, 233
Climate, 199
Cloud, 233
Coastal plain, 52, 88
Corrosion, 98
Consequent, 103
Crab hole, 134
Crater, 181
Crust. The outer covering of the globe.
Cumulus, 233
Cyclone, 214

DENUDATION. The removal of the surface rocks, whereby the underlying rocks are laid bare.
Devonian, 270
Diorite. An igneous rock composed of a felspar rich in lime and hornblende. The rock is composed entirely of crystals of these minerals, and it consolidated from a molten state under great pressure.
Dip. The inclination at which beds of rock slope downward into the earth.
Dip slope, 56
Doldrums, 213
Dunes. Hills of sand piled up by the wind.

EJECTED blocks, 185
Emergence, angle of, 166
Engrafting, 121
Erosion, 78, 98
Escarpment, 56

FAULT. A displacement of rocks along a fissue or crack.
Felspars. A group of minerals, which are constituents of most igneous rocks. Alkali-felspars contain much soda, or potash, or both, and little lime; basic felspars contain more lime than soda or potash.
Fiord, 57
Fissure eruption, 194

Flood plain. The alluvial plains beside rivers.
Fog, 233
Fold mountains. Mountains formed by the folding of beds of rock.

GEOID, 164
Granite. An igneous rock of deep-seated origin, and composed of the minerals—quartz, alkali-felspar, and mica.
Granodiorite. A similar rock to granite, but with a basic not an alkali-felspar.
Gypsum. A mineral composed of sulphate of lime and water; it is deposited on the evaporation of sea water.

HERCYNIAN. A former range of mountains, which once extended across western Europe from east to west; fragments of it still exist between Central Europe and the Atlantic coast.
Highlands, 56, 78
Homoseismic lines, 175

IGNEOUS. Formed by fire; the name of a group of rocks.
Ironstone. A rock containing much iron.
Isobar, 207
Isoseismic lines, 166
Isotherm, 203

KAINOZOIC, 269

LAND breeze, 209
Lapilli, 183
Lava. Rock that flows in a molten state from volcanoes.
Limestone. Rocks composed mainly of carbonate of lime.
Lithosphere. The hard rocky crust of the globe.

MALLEE. A district in north-western Victoria, named after the Mallee scrub (eucalyptus dumosa).
Massif, 72
Meander, 153
Meizoseismic area, 167
Melanochroi, 244
Meteorology. The study of the weather and climate.
Mist, 233
Monogenetic. A term applied to things which had the same origin.
Monsoon, 209-211
Moraine. The accumulation of rock debris found on or in glaciers.
Mudstone. A rock that weathers readily to mud.

NECK (volcanic), 181, 189
Negrito, 242
Negro, 242
Nimbus, 233
Nitrogen. A gas forming four-fifths of the volume of atmospheric air.

OBSEQUENT, 103
Obsidian. A volcanic glass, rich in silica.
Ordovician, 270
Origin, 166
Orogenetic. A term used for earth movements, which make mountains.
Oxygen. A gas forming about one-fifth of the volume of the atmosphere.

PAHOEHOE, 183
Palaeozoic, 239, 270
Papuan, 242
Pene-plain, 52, 78, 80
Plain of marine denudation, 52
Plateau, 53
Polygenetic. A term applied to things which had different origins.
Porphyries. Igneous rocks in which one of the constituent minerals occurs in crystals much larger than the rest.
Pumice, 182

QUARTZITE. A hard rock composed mainly of quartz grains cemented together. It is formed by the hardening or alteration of sandstone.

RADIATION, 205
Rand, 144
Rainfall. The amount of rain that falls at a locality during a given period—usually reckoned in inches a year.
Residual mountains, 54
Rias, 56

SANDSTONE. A rock composed of sand grains cemented together.
Scarp, 56
Scoria, 180, 183
Schist. A foliated rock which easily splits into thin sheets.
Sea breeze, 209
Sediment. Matter which settles at the bottom of water.
Sedimentary rocks. Rocks formed from matter which has been deposited by water or wind.
Seismic vertical, 166
Seismograph, 167
Shale. Hardened mud, which splits into layers along the lines of bedding.

GENERAL INDEX.

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